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NATIONAL DAM INSPECTION PROGRAM. FURNACE CREEK DAM (NATIONAL I.--ETC(U)
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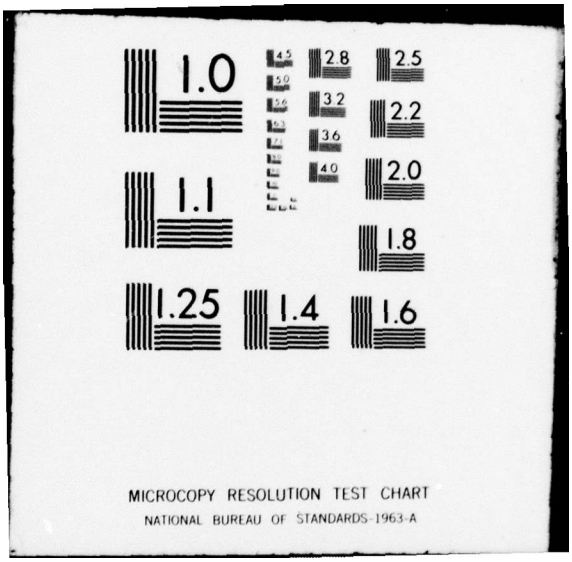
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SCHUYLKILL RIVER BASIN
FURNACE CREEK, BERKS COUNTY

PENNSYLVANIA
ID NO. PA. 00706

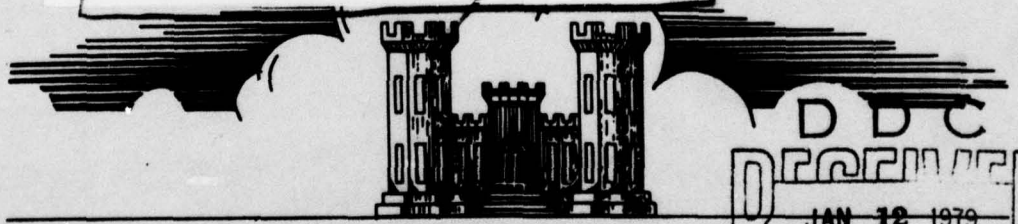
(10) John H. /Frederick, Jr.
William S. /Gardner

FURNACE CREEK DAM

(15) DACW31-78-C-0048

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

(6) National Dam Inspection Program. Furnace Creek Dam (National I.D. Number PA-00706), Schuylkill River Basin, Furnace Creek, Berks County, Pennsylvania. Phase I Inspection Report,



DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

(11) JUNE 1978

(12) 76p.

LEVEL II

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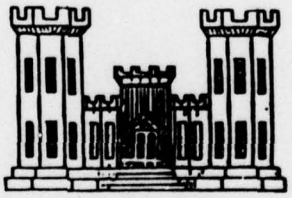
SCHUYLKILL RIVER BASIN

FURNACE CREEK DAM
BERKS COUNTY, PENNSYLVANIA
NATIONAL I.D. NO. PA 00706

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



Prepared by:

WOODWARD-CLYDE CONSULTANTS
5120 Butler Pike
Plymouth Meeting, Pennsylvania 19462

Submitted to:

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

June 1978

Contract DACW31-78-C-0048

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam: Furnace Creek Dam
County Located: Berks County
State Located: Pennsylvania
Stream: Furnace Creek
Coordinates: Latitude 40° 19.8' Longitude 76° 08.8'
Date of Inspection: 25 April 1978

Examination of Furnace Creek Dam resulted in the assessment that the facility is in good operating condition. No suspect conditions were noted that would give rise to immediate concern for the overall integrity of the dam.

Calculations indicate that the existing spillway system is not adequately designed to pass the probable maximum flood (PMF). However, the spillway capacity at present dam crest elevation is not judged to be "Seriously Inadequate" in that:

(1) it will pass about 76% of the probable maximum flood without overtopping failure, and

(2) the failure of the dam without overtopping would not significantly increase the hazard to loss of life downstream from the dam, from that which would exist just before overtopping failure.

It is recommended that the crest of Furnace Creek Dam, including the right abutment backfill, be raised to the top of the spillway walls. In this way the spillway is estimated to be capable of passing about 90% of the PMF.

The main area of concern identified during this study is the condition of the spillway walls. The right wall serves as an earth/rock retaining structure at the foot of the steeply sided natural abutment and the left wall retains the embankment fill. It appears that translation and/or rotation of more than one inch has occurred along the top of this wall since construction and exces-

sive stresses have caused structural cracking and separation between the wall and supporting buttresses. It is recommended that the stability of this wall be further evaluated.

Of less concern is the seepage at the downstream toe of the dam. It is recommended that a program of periodic documented observations be implemented to detect any possible changes in the seepage. Because this dam is virtually unattended throughout the year, a formal program of inspections should be implemented to assure that functional changes in the performance of the structure are noted.

A formal procedure for observation and warning during periods of high precipitation should be developed and implemented. Also, emergency operational procedures should be developed.

for John H. Frederick, Jr., P.E.
Maryland Registration 7301

30 June 1978
Date

W S Gardner

William S. Gardner, P.E.
Penna. Registration 43002E

6/30/78
Date

APPROVED BY:

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

11 Jul 78
Date

November 13, 1978 In reply refer to
6-446

John K. Schaeffer, Secretary
Womelsdorf-Robesonia Joint Authority
400 Lyman Avenue
Womelsdorf, PA 19567

Dear Mr. Schaeffer:

Thank you for your letter dated November 7, 1978 in response to our earlier correspondence on the Furnace Creek Dam located in Heidelberg Township, Berks County.

It is noted that you do not intend to implement our recommendations until sometime after July 1, 1979. This is entirely unsatisfactory. The items listed in our letter are recommendations that are considered essential to the continued safe operation of this dam.

It is requested that you advise this office by no later than November 17, 1978 of your intentions in this matter.

Sincerely yours,

Joseph J. Ellam, Chief
Dam Safety Section
Division of Dam Safety & Waterworks

JJE/ns
cc: Col. Withers w/c of letter
Gary Emanuel w/c of letter, Norristown Reg.
Geo. Parks, Reading Reg.
C. H. McConnell
file
30day
Dick Lamison, State Council of Civil Defense

NOV 9 1978

Womelsdorf - Robesonia Joint Authority

A WATER AUTHORITY – SUPPLYING WOMELSDORF, ROBESONIA AND SHERIDAN, PA.

Nov. 7, 1978

190 Lyon Avenue
Womelsdorf, Pa. 19567

Mr. Vaden R.Butler, Chief
Div. of Dams & Encroachments
Bureau of Water Quality Mgmt.
P.O.Box 2063
Harrisburg, Pa. 17120

Dear Mr. Butler: Re: File 6-446

This will reply to your letter of August 22, 1978 in which you ask for a schedule of when we plan on implementing the recommendations as outlined in your letter of July 27, 1978.

Your letter was discussed at our regular meeting of the Authority in September. It was agreed that our initial report would be furnished after the first annual inspection of the dam by our registered professional engineer. This is due no later than July 1st of each year.

Very truly yours,

John H. Schaffner
Secretary

JHS:sj
CC:H. Butz
B. Hindle
J. Hippo

OVERVIEW
FURNACE CREEK DAM

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
FURNACE CREEK DAM
NATIONAL ID #PA 00706

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Furnace Creek Dam is a zoned rolled earth and rock fill embankment approximately 372 feet long and 63 feet high at the original streambed. The dam was designed with a central core of impervious fill materials extending down to the rock surface. A reinforced concrete chute spillway for overflow discharge is located on the right abutment and described in greater detail in Section 1.3.i below. There is a reinforced concrete discharge culvert approximately 4 feet wide by 6 feet high beneath the dam for emergency draw-down capability. A 10-inch cast iron pipe for operating discharge from the reservoir is located within the discharge culvert. The operating and emergency discharge facilities are controlled by valves at the intake structure at the upstream toe of the dam.

b. Location. The dam is located on Furnace Creek approximately two miles south from the Borough of Robesonia in Berks County, Pennsylvania. The dam site and reservoir is shown on USGS Quadrangle, Womelsdorf, Pennsylvania, at coordinates N 40° 19.8', W 76° 8.8'. A Regional Location Plan of Furnace Creek Dam and Reservoir is enclosed as Plate 1 in Appendix E.

c. Size Classification. Intermediate (height is 63 feet and reservoir is 107 acre feet).

d. Hazard Classification. High hazard.

e. Ownership. Womelsdorf-Robesonia Joint Authority.

f. Purpose of Dam. Water supply for Womelsdorf, Robesonia and nearby communities.

g. Design and Construction History. Furnace Creek Dam was designed for the Owner by Glace and Glace, Inc. of Harrisburg, Pennsylvania. The available design drawings are dated November 10, 1958. A construction permit was issued on February 19, 1959 by the Water and Power Resources Board of the Commonwealth of Pennsylvania, Department of Forests and Waters. Construction was apparently started in Spring or Summer, 1959, and filling of the reservoir was begun in about late October, 1960.

h. Normal Operating Procedure. A minimum flow of 0.57 cfs is required to be discharged into Furnace Creek in accordance with the provisions of the construction permit. The gate on the emergency discharge is reported to be permanently open sufficiently to pass the minimum flow. Otherwise, the dam operations consist of leaving the water supply discharge valve open such that the discharge from the reservoir is then regulated by the demands of the distribution system.

1.3 Pertinent Data

a. Drainage Area. Approximately 3.8 square miles.

b. Discharge at Damsite.

Maximum known flood at damsite - 713 cfs (1)
Minimum required discharge - 0.57 cfs
Discharge at normal pool level - not known
Discharge at maximum design pool - 2,736 cfs
Maximum spillway capacity - 5,350 cfs, head = 11.5 ft.
Discharge conduit capacity - no rating curve

c. Elevation. (ft. above MSL) (2)

Top of Dam - 693.0

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(1) Estimated from verbal report of 3 feet of water over spillway during storm of July 9-10, 1970

(2) from design drawings

Maximum pool - design surcharge - 689.0
Maximum pool of record - 685.0 (estimated July 9-10, 1970)
Upstream portal discharge culvert - 635±
Streambed at centerline of dam - 630±
Maximum tailwater - no rating curve

d. Reservoir.

Length of maximum pool - 1,600± feet
Length of normal pool - 1,400± feet

e. Storage. (acre-feet)

Spillway crest - 107±
Top of dam - 188 (est.)

f. Reservoir Surface. (acres)

Spillway crest - 7.65

g. Dam Details.

Type - Rolled earth and rock fill with impervious soil core extending to rock.
Length - 372 feet
Height - 63 feet
Crest Width - 15 feet
Side Slopes - Upstream - 1:2.75 (V:H) above elevation 660
1:4 (V:H) below elevation 660
Downstream - 1:2.5 (V:H) above elevation 640
1:4 (V:H) below elevation 640

Zoning - Impervious clay core
Selected pervious material outer zones
Dumped rock fill toes
Impervious Core - Rolled clay fill, 10 feet wide at dam crest and increasing in width at 1:5 (H:V) with decreasing elevation down to dam foundation
Cutoff - Cutoff trench excavated to top of rock to minimum width of 10 feet and filled with extension of impervious clay core
Grout Curtain - Undefined grouting conducted in foundation excavation mentioned in State inspection memorandum

h. Diversion and Regulating Tunnel.

Type - Reinforced concrete culvert 4 feet wide and 6 feet high
Length - Approximately 360 feet
Closure - Manually operated sliding gate at intake structure
Access - Open at downstream end
Regulating facilities - 24 x 24 inch sliding gate at centerline, elevation 636.0

i. Spillway.

Type - Ogee crested weir
Length of Weir - 37.5 feet
Crest elevation - 682.0 feet
Gates - None
Upstream channel - Forebay with reinforced concrete walls, level concrete slab for 20± feet above crest, then unprotected soil and rock, increasing in width upstream from spillway.
Downstream channel - Reinforced concrete chute, 37.5 feet wide, walls 11 feet minimum high, slope of 1:3 (V:H).

j. Regulating Outlets.

Type - 10-inch CIP transmission line to distribution system for regulation
Intakes - 16-inch slide gate at elevation 668.0 (centerline)
18-inch slide gate at elevation 650.0 (centerline)
Access - Bridge to gate controls at top of intake structure

SECTION 2
ENGINEERING DATA

2.1 Design

a. Data Available. A detailed summary of engineering data on Furnace Creek Dam is presented in the checklist, attached as Appendix A. Engineering design data available for Furnace Creek Dam was contained primarily in a 25-sheet set of design drawings dated November 10, 1958. A set of these drawings is in the Owner's possession and microfilm copies are at the Commonwealth of Pennsylvania, Department of Environmental Resources, regional office in Reading, Pennsylvania. Additional engineering data was obtained from the files of the Department of Environmental Resources in Harrisburg, Pennsylvania.

Principal documents containing pertinent data are:

1. "Comments on Plans and Specifications", December 15, 1958

2. "Report Upon the Application of the Womelsdorf-Robesonia Joint Authority", January 21, 1959

3. Construction Permit, issued February 19, 1959

4. Miscellaneous memoranda, letters and visual inspection reports.

Within this data there was reference to, but no documentation of, physical and strength properties of embankment materials, engineering analysis of embankment stability, spillway capacity and design criteria, construction specifications, and construction of the dam.

b. Design Features. The principal design features of Furnace Creek Dam are illustrated on the Plan, Profile, and Cross-Section of the embankment that are enclosed in Appendix E as Plates 2, 3 and 4, and on Intake Tower Elevations, Plate 6, on the Plan and Profile of the spillway, Plate 5. These plates are reproduced from the November 10, 1958 set of drawings. The drawings show the embankment having a maximum height of 63 feet from a stream elevation on the order of 630 to a design crest elevation of 693. The dam contained a central vertical impervious core that is shown extending down to the top of rock. Although not shown

on any of the design drawings, other of the documents studied refer to a grout curtain extending into the rock beneath the core.

The upstream and downstream toes of the dam consist of rock fill zones with graded filter layers. The upstream slope of the dam is rip rap protected and the embankment slopes vary in inclination from 1:2.5 (V:H) to 1:4 (V:H). A reinforced concrete spillway with a crest elevation of 682 is located in the right abutment of the dam. The hydraulic parameters of the spillway are discussed in Section 5 below. The design drawings identify the spillway walls to be basically of a cantilevered design with uniform thickness and periodic exterior buttresses. The stilling basin discharges into the original course of Furnace Creek.

2.2 Construction.

The only available document pertaining to the dam construction is a memorandum dated October 27, 1959 reporting on a State inspection of the dam foundation excavation noting that grouting was in progress. During the site inspection, it was reported by Mr. Henry Lutz, the Owner's representative, that the Design Engineers, Glace and Glace, Inc. of Harrisburg, Pennsylvania, were retained for construction inspection. However, no construction reports were located. Isolated letters during the period of construction provide only general information about the dam. Mr. Lutz reported that the dam was constructed 50 feet further downstream than shown on the design drawings and that the crest of the dam was completed to the top of the spillway wall rather than 0.5 feet below the spillway wall as shown on the design drawing.

2.3 Operation Data.

A minimum flow requirement of 0.57 cfs in Furnace Creek was stated in the construction permit for the dam, together with a requirement that a weir be constructed to measure stream flow with measurements periodically reported to the State. The weir does not exist at the dam, and the Owner's representative reported that no records of the stream flow were maintained nor were any other records of the operation of the dam maintained. Memoranda of previous inspections by State personnel cite seepage at the left stilling basin wall.

2.4 Evaluation.

a. Availability. All engineering data reproduced in this report and studied for this investigation were provided by the

Pennsylvania Department of Environmental Resources. The Owner's representative was readily available to provide information about the construction and operation of the dam.

b. Adequacy. Due to the limited amount of detailed engineering data available, the final assessments of this investigation must be based primarily on the visual inspection, verbal reports of the dam operation, and the hydraulic analyses performed as part of this investigation.

c. Validity. It is reported that the borrow source for the dam embankment was located at the far end of the reservoir at some distance away from the borrow source that was apparently tested during the design of the dam. This information and the verbal report of the dam having been constructed 50 feet downstream from its design location together with the possibility of other undocumented design changes having been made leaves some doubt as to the absolute validity of the available design data.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The observations and comments of the field inspection team are contained in the checklist enclosed herein as Appendix B and are summarized and evaluated as follows. In general, the appearance of the facility indicated that the dam and its appurtenances were properly constructed and are well maintained.

b. Dam. During the visual survey, there were no indications or evidence observed of distortions in alignment or grade that would be indicative of movement of the embankment or foundation. A careful inspection of the dam disclosed no evidence of seepage emergence on the downstream slope. Minor seepages were observed along the base of the dam's rock toe at locations near the spillway and near the discharge tunnel. The actual sources of the small, clear-running seeps were obscured in the rock fill toe of the dam. The approximate locations of the observed seeps are shown on a plan in Appendix B.

It was observed that the crest of the dam was about one foot below the top of the spillway wall. The design drawings indicated the dam crest to be 0.5 feet below the spillway wall so that this observation would indicate about 0.5 feet of settlement adjacent to the spillway. However, the Owner's representative reported that the dam crest was constructed level with the top of the spillway wall so that this observation would indicate about one foot of settlement at this location. Additional observations on the downstream face disclosed a maximum of about one foot of embankment settlement adjacent to the spillway wall.

c. Appurtenant Structures. At the time of the inspection, not more than one inch of water was flowing over the spillway. The spillway flow was observed to be reasonably smooth and uniform over the crest and down the spillway channel. Some minor concrete spalling was observed at occasional joints in the floor slab of the spillway and in the spillway walls. The spillway walls were observed to be not in a straight line, either as a result of the workmanship in setting the concrete forms during construction or as the result of movement of the walls.

Close inspection revealed differential rotation between panels of the spillway walls with a maximum differential deflection on the order of 1.5 inches at construction joints at the

top of the spillway walls. Concrete cracks up to 1/4 inch wide were observed at two of the buttresses on the spillway walls. These cracks appeared to propagate from the re-entrant corners of the buttress and are approximately parallel to the face of the spillway wall.

Inspection within the discharge culvert disclosed the concrete to be in relatively good condition without any signs of major cracking, spalling or deterioration. At about the centerline of the dam there were several minor seepages that resulted in dampness on the tunnel walls but were not sufficient to produce any observable flow. Occasional calcium carbonate stalactites were also observed in the tunnel. At two locations near the dam centerline, very soft red-brown clayey silt had extruded through cracks in the walls of the tunnel. About 0.1 cubic feet of this material had accumulated on the tunnel wall and the concrete in the immediate areas was observed to be stained a dark red-brown. At the outlet of the discharge culvert, erosion of the soil underlying the rip-rap protection was observed.

d. Reservoir. Reconnaissance of the reservoir disclosed no evidence of siltation, slope instability, or other features that would significantly affect the flood storage capacity of the reservoir. Some minor sandbar formation was observed at the upper end of the reservoir where two smaller creeks and Furnace Creek entered the reservoir.

e. Downstream Channel. Downstream of the stilling basin, Furnace Creek flows in a rocky streambed with no evidence of major erosion, although localized undercutting was observed in isolated areas of the stream channel. The stream flows in a narrow fairly steep sided valley that presents no major obstructions to large volumes of water flow. Approximately 0.8 miles downstream from the dam, the valley widens into a flood plain where approximately two dozen houses are located. This flood plain leads into Robesonia within a further distance of about one mile. With these downstream residential areas, there is a potential for property damage and some loss of life in the event of an exceedingly large volume of flow. Thus, Furnace Creek Dam is classified as a High Hazard structure.

3.2 Evaluation.

The survey of the dam disclosed no evidence of apparent past or present movement of sufficient magnitude to indicate instability of the dam embankment. The observations at the dam crest and downstream face could represent a general settlement of the dam embankment or a localized settlement of backfill against the spillway structure. The small seeps observed at the downstream toe of the dam do not appear to be associated with potential piping as evidenced by the clear water observed. However, the absence of documented past observations or flow records gives no baseline for judgement of changes in this seepage with time. The cracks observed at the buttresses are believed to represent a tensile separation of the spillway wall from the supporting buttress. The conditions observed within the discharge conduit do not appear to represent an immediate hazard to the integrity of the dam.

SECTION 4
OPERATION PROCEDURES

4.1 Procedures.

The maximum reservoir level is regulated by discharge over the spillway with design crest elevation of 682.0. Water for public consumption use is drawn off through the 10-inch pipe with the flow apparently regulated by the demands of the distribution system removed from the dam. A shut-off valve for this pipe is located in the intake structure and is reportedly left constantly open. It was reported that the gate on the discharge conduit is left open to sufficiently maintain the minimum flow in Furnace Creek. With these operations procedures, the dam is unattended by the Owner's personnel except for maintenance work and infrequent visits. It is understood from the Owner's representative that no written procedures exist for the operation of the Furnace Creek Dam.

4.2 Maintenance of Dam.

The dam is reportedly maintained by the Owner's personnel who periodically mow the grass growing on the downstream face of the dam.

4.3 Maintenance of Operating Facilities.

The valve control mechanisms and the bridge to the intake tower are clean; painted and lubricated as needed to insure proper operation and indicate periodic maintenance.

4.4 Warning Systems in Effect.

There are no formal warning systems or procedures established to be followed during periods of exceedingly heavy rainfall. Full time attendence at the dam during heavy rainfall was not reported by the Owner's representative.

4.5 Evaluation.

It is believed that the current operating procedures are a reasonably realistic means of operating the relatively simple control facilities of Furnace Creek Dam. A formal warning procedure to be implemented during periods of extreme rainfall should be formulated so that residents downstream could be amply warned of possible high volumes of flow in Furnace Creek.

SECTION 5
HYDRAULIC AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. The hydraulic and hydrologic design data for Furnace Creek Dam were found in the report of the permit application for the dam construction, dated January 21, 1959. The drainage area, as described in the application report and confirmed on current USGS topographic maps, is approximately 3 miles long and 1.2 to 1.7 miles wide and covers an area of about 3.8 square miles. Elevations in the drainage area range from 1,120 feet in the upper reaches to 680 feet just above the dam. The watershed area is mountainous, sparsely populated, and approximately 50 percent wooded.

As determined from the State files, the spillway capacity with a head of 11.5 feet, was rated as 5350 cfs, although the construction drawings indicate a maximum possible head of 11 feet. The required spillway capacity, as stated in the permit application report, and based on drainage area alone was 2736 cfs.

b. Experience Data. The only historical records of flow that could be reasonably obtained is a memorandum dated July 24, 1970 in the State file referring to a water flow 3 feet over the spillway during a rain storm of July 9-10, 1970. This water depth corresponds to an estimated discharge of 713 cfs.

c. Visual Observations. As presented in Appendix B, no features were observed in the reservoir or downstream channel that would adversely affect the hydraulic and hydrologic conditions. However, apparent settlement of the dam was observed such that the maximum pool up to dam crest is on the order of 10.3 feet above spillway crest rather than 11 feet as designed. Based on the small number of fallen trees in the surrounding woods, clogging of the spillway with debris is considered to be unlikely.

d. Overtopping Potential. A detailed analysis of the hydraulic and hydrologic conditions of Furnace Creek Dam is presented in Appendix C. Because of the lack of readily available data for a State-Of-The-Practice evaluation, an estimated PMF peak inflow rate was supplied by the Corps of Engineers and the volume of inflow estimated using information contained in the National Weather Service Technical Paper 40. A peak inflow rate of 5930 cfs was used along with the

volume of a triangular inflow hydrograph approximation computed from the estimated volume of runoff resulting from the PMF as determined from TP-40. A flood routing was performed following the procedures contained in the Corps of Engineers' "Preliminary Engineering Technical Letter No. 1110-2", dated January 25, 1978.

The foregoing approximate methods indicate a spillway design flood of less than the PMF and more than 0.5 PMF. More than two feet of freeboard was estimated to exist with the 0.5 PMF event. Analyses of spillway capacity at various elevations of the dam embankment crest and the portion of the PMF that can be passed are summarized in Table 5.1 below.

TABLE 5.1
SUMMARY OF SPILLWAY CAPACITY

DAM CREST ELEVATION	MAXIMUM SPILLWAY HEAD WITHOUT OVERTOPPING, ft.	SPILLWAY FLOW, cfs	PORTION OF PMF FLOW
Present	10.25	4,500	76%
As Designed	11.0	5,017	84%
Dam Crest at Top of Spillway wall	11.5	5,350	90%

Assuming the 24-inch square sliding gate to be a freely discharging orifice, a maximum flow on the order of 145 cfs is obtained. However, flow restriction in the discharge culvert and a tailwater that might submerge the culvert are expected to reduce this flow considerably. Also, it is possible for the access road to the dam to become impassable during periods of extreme flow. Thus, it is not considered prudent to expect significant additional discharge capacity from the outlet works during periods of extreme precipitation.

Just prior to an overtopping event, the tailwater is estimated to be 40 feet below the spillway crest. Consistent with the hazard potential as discussed in Section 3.1, e., and the size classification of the dam and reservoir, the recommended criteria require that Furnace Creek Dam be capable of passing the PMF without overtopping. Based on this analysis, Furnace Creek Dam does not meet the criterion and is considered "Inadequate", but is not considered to be "Seriously Inadequate" as it will pass 0.5 PMF.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. The visual observations did not indicate any existing embankment stability problems. However, small seeps (estimated to be less than 6 gpm each) were observed at five locations at the toe of the dam. The clarity of the seepage water indicates that piping or erosion within the dam is not occurring. However, the lack of records of past seepage observation gives no basis for judging whether changes have or have not occurred. Similarly, there is no record of the soil intrusion into the drainage culvert to provide any basis for judging whether or not this occurrence is indicative of progressive erosion within the dam. Neither were there other observations to correlate with the soil intrusion as evidence of a serious hazard to the dam.

b. Design and Construction data. Within the review comments, it was pointed out that the proposed borrow area was located immediately upstream from the dam and samples taken from borings and test pits in this area were apparently tested to determine the design and shear strength parameters. A safety factor of 1.2 was cited as having been obtained from an analysis from the upstream slope under rapid draw-down condition and the recommendation was made that the dam design be modified to its present design configuration so that a higher safety factor would be expected. Consistent with the reported change in borrow material source for the embankment construction, there is reason to believe that the design stability analyses referred to in the available data may not be representative of the embankment that was constructed. However, considering the slope inclinations, the rock toes, the graded filters, and the impervious core, the design features of the dam appear adequate.

The brief construction report of the foundation excavation indicates that grouting was performed so that the imperviousness of the dam foundation would be reasonably certain. The anti-seepage collars around the spillway and discharge culvert appear to be adequate to preclude a preferred seepage path along these structures.

c. Operating Records. Verbal reports of the performance of the dam gave no indication of any hazard associated with the operation of the dam.

d. Post-Construction Changes. There were no reports nor is there any evidence that modifications or alterations were made to the dam.

e. Seismic Stability. This dam is located in Seismic Zone I. Normally, it can be considered that if a dam in this zone is stable under static loading conditions, it can be assumed safe for any expected earthquake loading. Thus, the same qualifications to the static stability of Furnace Creek Dam also apply to the condition of seismic stability.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The visual inspection and the long-term performance of Furnace Creek Dam indicates that the dam embankment and foundation has and is performing satisfactorily. The clear seeps at the toe of the dam do not at present indicate a serious hazard to the integrity of the dam. However, the lack of measurement records of this seepage precludes any evaluation of change with time. The concrete cracks at the spillway wall buttresses are believed to represent a defect in the structure, but not necessarily an immediate hazard to the safety of the dam. Similarly, while the conditions within the discharge culvert are indicative of structural discontinuities, these features do not appear to represent a serious hazard to the integrity of the dam.

The approximate hydraulic and hydrologic analyses conducted as part of this study indicate that the dam would be overtopped by a PMF event. The spillway capacity, therefore, is classified as "Inadequate". However, these analyses do indicate that one half of the PMF can be passed by the spillway without overtopping the dam. Thus, the spillway capacity by definition does not have a "Seriously Inadequate" classification.

b. Adequacy of Information. The information available is such that the assessment of the condition of the dam embankment must be based primarily on the visual inspection and approximate hydraulic analysis.

c. Urgency. It is considered that the recommendations presented below be implemented as soon as practicable.

d. Necessity of Additional Studies. Although the data did not include summaries of the stability analyses of the embankment, the visual inspection of the embankment does not indicate that additional stability studies are needed. However, other studies should be performed as needed to implement the remedial measures.

7.2 Remedial Measures.

a. Alternatives. Consistent with the present criteria

for dam inspections, the most serious defect of Furnace Creek Dam is related to the capacity of the spillway. In its present condition, Furnace Creek Dam is capable of passing about 0.76 PMF. It is believed that the present criteria could be satisfied by raising the crest elevation of the dam by at least two feet. Alternately, an emergency overflow spillway could be constructed in the left abutment area of the dam.

As a more feasible means of upgrading the hydraulic capacity of Furnace Creek Dam, it is recommended that the dam crest be raised to the top of the spillway wall. Also, the backfill behind the right spillway wall should be similarly raised. After this work is performed, the spillway is expected to be capable of passing 0.9 PMF. Additional protection against overtopping during the PMF event could be obtained by riprapping or otherwise armoring the downstream slope of the dam.

The cracks in the buttresses should be studied through an analysis of the spillway wall structure. At a minimum, these cracks should be sealed to preclude water intrusion and concomitant seasonal freezing damage. Depending upon the results of further analyses, measures such as installing tie-back anchors might be necessary.

The cracks in the discharge culvert should be sealed to preclude further soil intrusion. Pressure grouting through the walls of the culvert is expected to seal the cracks and fill any possible voids outside of the culvert. A program of periodic inspection of the downstream seepage should be implemented. Photographs and a written evaluation of the seeps (including an estimate of the seepage rate) should be periodically made and compared with the previous such observations.

b. Operation and Maintenance Procedures. Because of the location of the dam upstream from a populated area a formal procedure of observation and warning during periods of high precipitation should be developed and implemented. The Owner should also develop an operational procedure to follow in the event of an emergency.

APPENDIX

A

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM *Furnace Creek Dam*

ID # *Pa 00706*

ITEM	REMARKS
AS-BUILT DRAWINGS	*None available.*
REGIONAL VICINITY MAP	*U.S.G.S. Quad Sheet entitled "Womelsdorf, Pennsylvania".*
CONSTRUCTION HISTORY	*Documentation not available.*
TYPICAL SECTIONS OF DAM	*This information is in Owner's possession and is also available at Pennsylvania Department of Environmental Resources, Reading regional office as "Typical Section, Furnace Creek Dam" Sheet 11, November 10, 1958.*
OUTLETS - PLAN DETAILS	*Plans and details are contained within the 25 sheet set of design drawings that are in the Owner's possession and also available at the Pennsylvania Department of Environmental Resources, Reading regional office.*
CONSTRAINTS DISCHARGE RATINGS	*Minimum flow of 0.57 cfs required by construction permit issued by Pennsylvania, Department of Forests and Waters, Water and Power Resources Board, issued on February 19, 1959.*
RAINFALL/RESERVOIR RECORDS	*Not maintained.*

ITEM	REMARKS
DESIGN REPORTS	*No design reports were available for review.*
GEOLOGY REPORTS	*Geologic literature and reports indicate the dam to be built upon Precambrian granite gneiss. Diabase dikes occur in the area and were observed in the right abutment area. Rock foliation strikes N 86° E and dips 32° to the south (upstream). High angle NE and NW striking joints were observed.*
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	*Not available for review. Reference to these is made in comments from State application review (1958).*
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	*Some stratigraphic column logs are shown on design drawings. Otherwise, data was not available for review. Reference is made to some of these data in comments from State application review (1958).*
POST-CONSTRUCTION SURVEYS OF DAM	*None reported, although dam was verbally reported to be constructed 50' downstream from plan location.*
BORROW SOURCES	*Located within reservoir area at upper end.*

ITEM	REMARKS
MONITORING SYSTEMS	*None.*
MODIFICATIONS	*Undocumented modifications may have been made to design during construction.*
HIGH POOL RECORDS	*None kept, although verbal reports were given of never more than 3' of water passing over spillway.*
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	*None reported.*
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	*None.*
MAINTENANCE OPERATION RECORDS	*None reported.*

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	*The design plans were made available by the Owner and reviewed during the inspection.*
OPERATING EQUIPMENT PLANS & DETAILS	*The operating equipment was noted and inspected.*

APPENDIX

B

CHECK LIST
VISUAL INSPECTION
PHASE I

Name Dam *Furnace Creek Dam* County *Berks* State *Pennsylvania* National ID # *Pa 00706*

Type of Dam *Zoned Earth and Rock* Hazard Category *I (HIGH)*

Date(s) Inspection *4/25/78* Weather *Clear* Temperature *70°±F*

Pool Elevation at Time of Inspection *682.2±* M.S.L. Tailwater at Time of Inspection *623.3±* M.S.L.

Inspection Personnel:

John H. Frederick, Jr. (Geotechnical) *Mary F. Beck (Hydrologist)*

Richard E. Mabry (Geotechnical) *Vincent McKeever (Hydrologist)*

Raymond S. Lambert (Geologist)

Richard E. Mabry Recorder

Remarks:

Pool and tailwater elevations were measured with respect to elevations shown on spillway structure drawings.

Owner's Representative was Henry Lutz, President of Water Board.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	*N/A*	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	*N/A*	
DRAINS	*N/A*	
WATER PASSAGES	*N/A*	
FOUNDATION	*N/A*	

CONCRETE/MASONRY DAMS

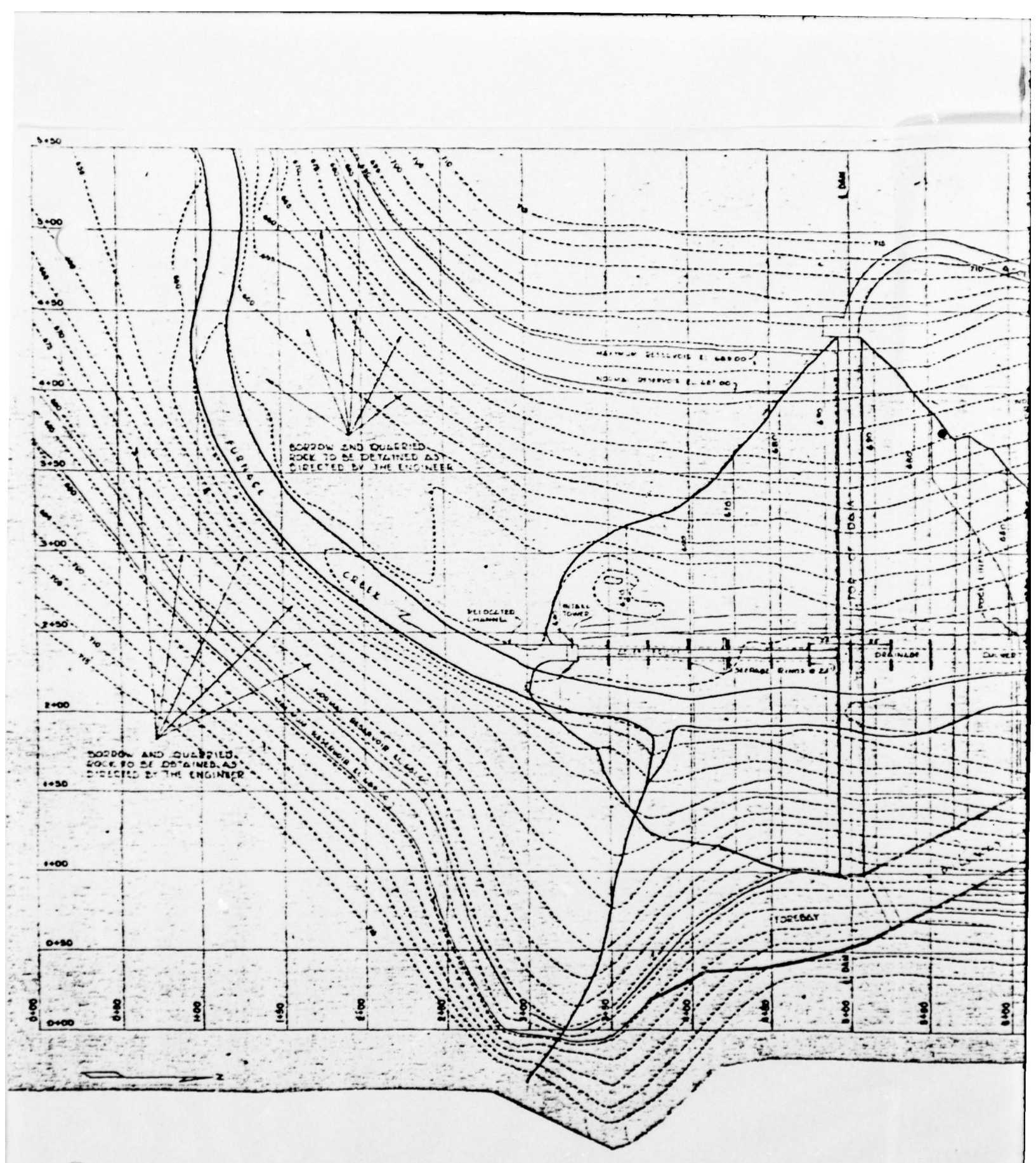
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	*N/A*	
STRUCTURAL CRACKING	*N/A*	
VERTICAL AND HORIZONTAL ALIGNMENT	*N/A*	
MONOLITH JOINTS	*N/A*	
CONSTRUCTION JOINTS	*N/A*	

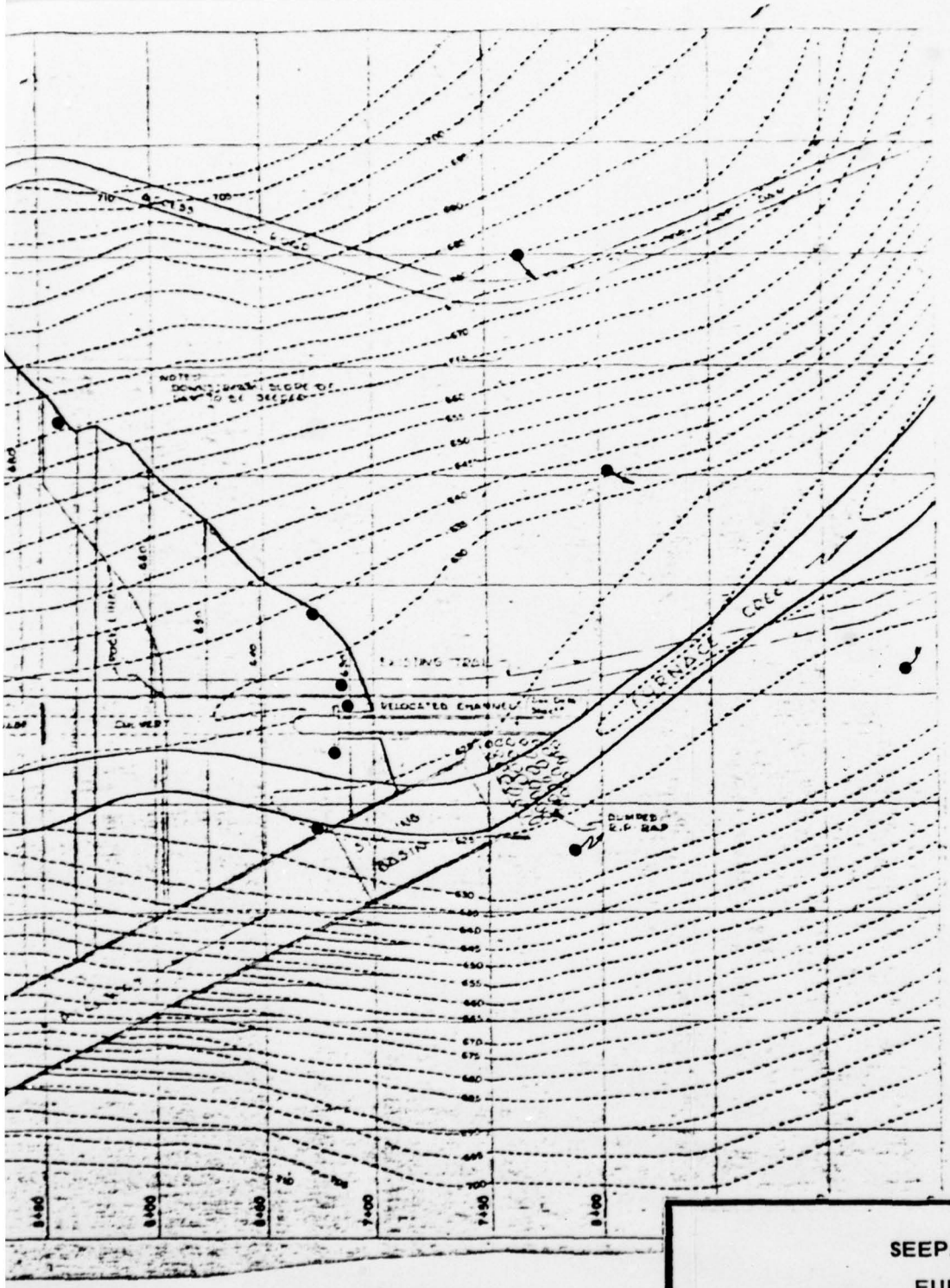
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	*None observed*	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	*None observed*	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	*None observed*	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	*Horizontal alignment along the crest is straight. The crest of the dam is about one foot below the top of spillway wall. Based on design drawings and visual observation, it appears that crest has settled 0.5 feet. Accordingly to Mr. Lutz the dam settled approximately 1 foot. (See Photo No. 7).*	
RIPRAP FAILURES	*None observed*	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	*Settlement of embankment/backfill observed at left spillway wall - 0.5' to 1.0' at dam crest. (See sheet 4, item 4 for explanation). Settlement as much as 1' at first buttress down from crest. (See Photo No. 8)*	
ANY NOTICEABLE SEEPAGE	*Clear water seepage at several locations. Seepage is ponded adjacent to left stilliny basin wall with water level 3±' above water level in stilling basin. There are several seeps around discharge culvert and 20' to 30' to left of tunnel. Soft area and seepage at left abutment near valley bottom. Sources of seeps were obscured within rock toe. Volume of individual seeps estimated to be less than 5 gpm since no gauging is installed. Spring observed on access road about 300' from dam.*	
STAFF GAGE AND RECORDER		
DRAINS	*Water draining from stilling basin seep through weep hole in basin wall. (Seepage is clear). Relief drains in spillway slab on embankment side only.*	





LEGEND:

- ● SEEPAGE LOCATION
- ↗ NATURAL SPRING AS NOTED ON 4/25/78

SEEPAGE LOCATION PLAN

FURNACE CREEK DAM

NAT. ID NO. PA.00706 BERKS COUNTY

BASE MAP FROM GLACE AND GLACE CONSULTING ENGINEERS DESIGN DRAWINGS SHEET 9 OF 25, DATED 10 NOV. 1958

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	*Concrete in outlet tunnel is generally good although a few hairline to 1/16" cracks were observed in roof and walls. There are a few minor seeps of water into tunnel, two areas at about dam$_3$ centerline where very soft red-brown clayey silt extruded into tunnel with about 0.1'^{3} accumulated on wall, and a few areas of dark brown-black staining on walls. Some $CaCO_3$ stalactites.*	
INTAKE STRUCTURE	*Bridge to valve controls in apparently good condition. Valves are underwater at upstream end of intake and controls were exercised.*	
OUTLET STRUCTURE	*N/A*	
OUTLET CHANNEL	*Some erosion of soil under rip rap at tunnel outlet--no other dissipator or protection exists.*	
EMERGENCY GATE	*Reported to be left slightly open to maintain low water flow in creek--gate exercised.*	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	*Concrete is generally in good condition with no erosion or spalling. About 1" of water was flowing uniformly and smoothly over crest and down chute. Measured width of 37.5' agrees with design drawings.*	
APPROACH CHANNEL	*Rock cut at right side of channel exhibited loosened and fallen pieces of rock. In right wall of dam crest there is a tension crack propagating from re-entrant corners at buttress and parallel to wall face. (See Photo No. 6) Otherwise, concrete appears in good condition.*	
DISCHARGE CHANNEL	*Width measured to be 37.5' with floor slab in generally good condition. Both spillway channel walls are not in straight alignment--either a construction feature or evidence of movement. (See Photo No. 4). Differential rotation of wall sections was observed at construction joints with a maximum displacement of 1.5" at top of wall. (See Photo No. 5). Cracks observed at mid panel were wider on spillway side and extended vertically down face of wall. Tension cracking was observed at buttress/wall juncture on left wall with a maximum opening of 1/4". (Similar to Photo No. 6).*	
BRIDGE AND PIERS	*None*	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	*N/A*	
APPROACH CHANNEL	*N/A*	
DISCHARGE CHANNEL	*N/A*	
BRIDGE AND PIERS	*N/A*	
GATES AND OPERATION EQUIPMENT	*N/A*	

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	*B.M. elevation 697.95 painted on top of left spillway wall does not correspond to design wall elevation 693.5 on drawings.*	
OBSERVATION WELLS	*None installed.*	
WEIRS	*None installed.*	
PIEZOMETERS	*None installed.*	
OTHER	*There were no rain gages or flow measurement records. However, the State construction permit (dated February 19, 1959, issued by the Water and Power Resources Board of the Department of Forrests and Waters) indicates that minimum flows are required and flow records should be sent to the Board on a regular basis. Mr. Lutz did not know of this requirement and there were no records found in the State files.*	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	*The reservoir slopes are steep, stony and stable with woods coming close to the water's edge. Very few fallen trees present a negligible chance for trees floating in reservoir and clogging the spillway during a large storm. Minor sloughing of slopes was observed in borrow area at upper end of reservoir. This area was recently planted with pine trees for stabilizaton.*	
SEDIMENTATION	*There are sand bars where two small streams and Furnace Creek enter the upper end of the reservoir. Sedimentation appears to have negligible effect on available flood storage.*	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	*Immediately downstream from stilling basin, the channel is rocky and shows no evidence of erosion or other problems. Further downstream, the channel is contained within a narrow valley and has a fairly steep gradient. There are no obstructions or apparent problems with debris for about one mile downstream.*	
SLOPES	*The stream banks and channel bottom are rocky and the banks appear to be stable but with some minor areas of undercutting that should not create any problems.*	
APPROXIMATE NO. OF HOMES AND POPULATION	*At a distance greater than one mile downstream there are numerous houses adjacent to Furnace Creek. New houses are being built in the flood plain area.*	

APPENDIX

C

FURNACE CREEK DAM
CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: *50 percent wooded, mountainous*

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): *682 - design*

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): *10'3" above spillway crest*

ELEVATION MAXIMUM DESIGN POOL: *689.0 - design*

ELEVATION TOP DAM: *693.0 design - crest now about 692.5 - design datum*

SPILLWAY:

a. Elevation *682.0 design spillway*

b. Type *Concrete chute spillway with 2 ft. high ogee weir*

c. Width *N/A*

d. Length *37.5' spillway weir*

e. Location Spillover *Right abutment*

f. Number and Type of Gates *None*

OUTLET WORKS: *(Water Supply)*

a. Type *Water supply pipe to service area*

b. Location *Through diversion/emergency drawdown culvert*

c. Entrance inverts *Submerged inlet*

d. Exit inverts *N/A*

e. Emergency draindown facilities *Gate at end of 4' x 6' diversion culvert*

HYDROMETEOROLOGICAL GAGES: *None*

a. Type

b. Location

c. Records

MAXIMUM NON-DAMAGING DISCHARGE: *Not determined*

DAM SAFETY ANALYSIS
HYDROLOGIC/HYDRAULIC DATA

Date: 4/24/78
By: MEB
Sheet 2 of 10

DAM Furnace Creek Nat. ID No. PA00706 DER No. 6-446

ITEM/UNITS	Permit/Design Files (A)	Calc. from Files/Other (B)	Calc. from Observations (C)
1. Min. Crest Elev., ft.	693.0		
2. Freeboard, ft.	0		
3. Spillway(1) Crest Elev, ft.	682.0		
3a. Secondary(2) Crest Elev, ft.	-		
4. Max. Pool Elev., ft.	689.0		
5. Max. Outflow(3), cfs	5350 cfs @ H=11.5 ft		
6. Drainage Area, mi²	3.8 sq.mile	3.76 sq.mile	3.81 sq.mile
7. Max. Inflow(4), cfs		6180 cfs	
8. Reservoir Surf. Area,	7.9 ± Ac.		7.65 Ac.
9. Flood Storage(5),			78.4 Ac-Ft.
10. 6 hr PMP - TP-40		25.5 inches	

Reference all figures by number or calculation on attached sheets:

Example: 3A - Drawing No. xxx by J. Doe, Engr., in State File No. yyyy.

NOTES:

(1) Main emergency spillway.

(2) Secondary ungated spillway.

(3) At maximum pool

(4) For Columns B, C, use PMF.

(5) Between lowest ungated spillway and maximum pool.

Date: 4/24/78
By: MFB
Sheet 3 of 10

HYDROLOGIC/HYDRAULIC CALCULATIONS (cont.)

Item (from page 1)	Source
6A, 5A, 8A	Application Report Jan. 1959
6B	Calculation on "Memo to File", dated Feb. 7, 1958
6C, 8C	USGS Map Womelsdorf, PA. (1969)
2A	Calculation Sheet in file, performed by Dept. of Forest and Water - Water and Power Resources Board
1A, 3A	Design elevations from Glace & Glace Dwg. dated Nov. 1958
4A,	Glace & Glace Dwg. of Centerline Profile of Dam
10B	PMP - TP 40 Chart 50
9B	See Sheet 5 of 9
7B	See Sheet 4 of 9

BY MFB DATE 5/15/78 Revised 6/23/78 SUBJECT Furnace Creek Hydrology/Hydraulics SHEET 4 OF 10

CHKD. BY DATE JOB No.

Discharge of Spillway

$Q = CLH^{3/2}$

Q = 5350 cfs
L = 37.5 ft.
H = 11.5 ft
} information contained in Application Report dated Jan. 21, 1959

$5350 \text{ cfs} = C \cdot 37.5 \cdot 11.5^{3/2}$

$C = 3.66$ assume constant with head

Q	H	
4500 cfs	10.25 ft.	existing conditions
5007 cfs	11.0 ft.	max. head - design drawings
5350 cfs	11.5 ft.	dist. between spillway crest and wall

PMF

Peak Inflow - Q_I

$Q_I = 6180$ cfs on Furnace Creek w/ D.A. = 4.0 mile^2
AN ESTIMATED VALUE SUPPLIED BY C of E, PHILA. DIST.

Actual D.A. = 3.8 mile^2, therefore,

$$Q_I = \left(\frac{3.8}{4.0}\right)^{0.8} 6180$$

$$= 5930 \text{ cfs} - \text{ESTIMATED PMF PEAK INFLOW}$$

Volume of Runoff

TP-40 6 hr, 10 sq. mile PMP = 25.5 inches

assume 90% run off

Runoff = 25.5 × 0.9 ≈ 23 inches

BY MFB DATE 6/25/78 SUBJECT Furnace Creek Dam SHEET 5 OF 10

CHKD. BY DATE Hydrology / Hydraulics JOB No

Discharge through orfice - 2'x2', invert elev. 635

Maximum possible discharge would occur if orfice discharges freely

$Q = C a \sqrt{2gh}$

assume $h = 693.5 - 636 = 57.5$ ft

assume $C = 0.6$ Table 4-3 King & Brater Handbook

$Q = 0.6 \cdot 4 \cdot \sqrt{2g\,57.5}$

$= 146$ cfs

Estimated discharge at PMF

Estimated Tailwater Elev. 642
assuming no frictional losses in conduit

$h = 693.5 - 642 = 51.5$

$Q = 0.6 \cdot 4 \sqrt{2g\,51.5}$

$= 138$ cfs

Therefore; discharge thru conduit would be less than 138 cfs

DAM SAFETY ANALYSIS
HYDROLOGIC/HYDRAULIC CALCULATIONS

Date: 5/15/78 Rev. 6/25/78
By: VM/MFB
Sheet 6 of 10

DAM Furnace Creek Nat. ID No. PA 706 DER No. 6-446
Calculations for *Design* ☐, *As-Built* ☐, *Existing* ☐ Conditions

1. Spillway Discharge at Max. Pool*, Q_{omac} 5350 cfs sheet # of 9
   Freeboard at Max. Pool 0 ft.

2. Tributary Drainage Area , A 9.8 mi^2

3. From Corps
   Inflow hydrograph peak flow, Q_{Imax} 5930 (est.) (2965) cfs at 100% (50%) PMF

IF Q_{omax} exceeds Q_{Imax}, check here and stop ☐ (✓ for 50 % PMF)

4. Calculate $p = Q_{omax}/Q_{Imax}$ = 5350/5930 = 0.9022.

5. Calculate Volume of inflow hydrograph, V_I

   V_I = $\frac{23}{12} \times 9.8 \times 640$ = 4661 Ac-Ft (2331)

6. Calculate volume of storage between normal and maximum pool, V_s

   Crest Elevation = _____ ft.
   Freeboard** = _____ ft.
   El. Max. Pool = _____ ft.
   El. Normal Pool** = _____ ft.
   Storage Height = 11.5 ft. recommended height

   Area of reservoir from USGS quad sheet , 7.65 Ac

   V_s = Storage Height x Area = 88.0 Ac-Ft Note: Available flood water storage is somewhat greater because of reservoir side slopes (side slopes are steep)

IF V_s exceeds V_I, check here and stop ☐.

* *Attach calculations or source.*
** *Attach justification for values selected.*

HYDROLOGIC/HYDRAULIC CALCULATIONS (cont.)
DAM Furnace Creek
Design ☐, *As-Built* ☐, *Existing* ☑

Date: 5/15/78 Rev. 6/25/78
By: VM/MFB
Sheet 7 of 10

7. Calculate storage required to pass flood, V_R

$V_R = (1-p)\ V_I$ = (1 - .9022) x 4661 = 455 Ac-Ft.

IF V_S exceeds V_R, check here and stop ☐ .

8. Calculate freeboard storage, V_F

V_F = Freeboard x Area = _____ x _____ = 0 ft^3

Does V_R exceed $V_S + V_F$? yes . If yes, repeat for 1/2 PMF, if this calculation is for 1/2 PMF, and answer is still yes, dam may be unsafe.

SUMMARY

Dam passes
- PMF with _____ ft. freeboard . . . ☐
- PMF with no freeboard . . . . . ☐
- 1/2 PMF with _____ ft. freeboard . ☐
- 1/2 PMF with no freeboard . . . . . ☐
- None of the above . . . . . ☐

BY MFB DATE 5/15/78 SUBJECT SHEET 8 OF 10

CHKD. BY DATE Hydrology / Hydraulics JOB No

Furnace Creek

Estimate Freeboard During 0.5 PMF

assume 2.5 ft. freeboard

$V_S = (10.25 - 2.5)\,7.65 = 59.3$ Ac-Ft.

set $V_S = V_R$

$$59.3 = \left(1 - \frac{Q_o}{3090}\right) 2331$$

$$Q_o = 3011 \text{ cfs}$$

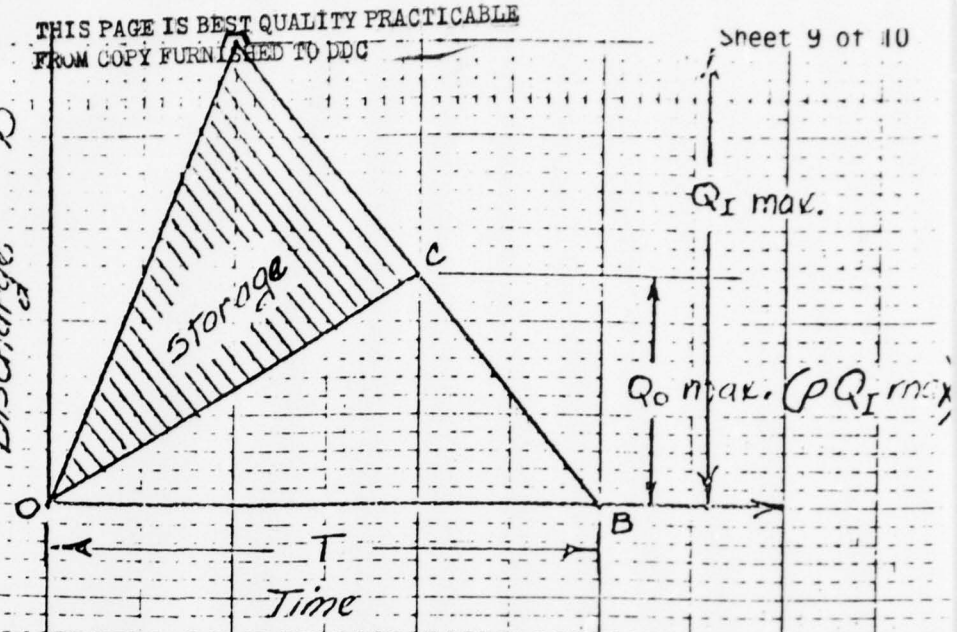
$$Q = CLH^{3/2}$$

$$3011 = 3.66 \cdot 37.5 \cdot H^{3/2}$$

$$H = 7.83 \text{ ft}$$

$7.83 + 2.5 = 10.33$ ft $\sim$ 10.25 ft measured value

the above corresponds to a freeboard of 9.75 ft if the dam crest is raised to the top of the spillway wall



PURPOSE: Establish relationship between maximum spillway discharge and storage required to pass flood hydrograph without exceeding maximum pool level.

$$\frac{\Delta AOC}{\Delta AOB} = \frac{\Delta AOB - \Delta COB}{\Delta AOB} = 1 - \frac{\Delta COB}{\Delta AOB}$$

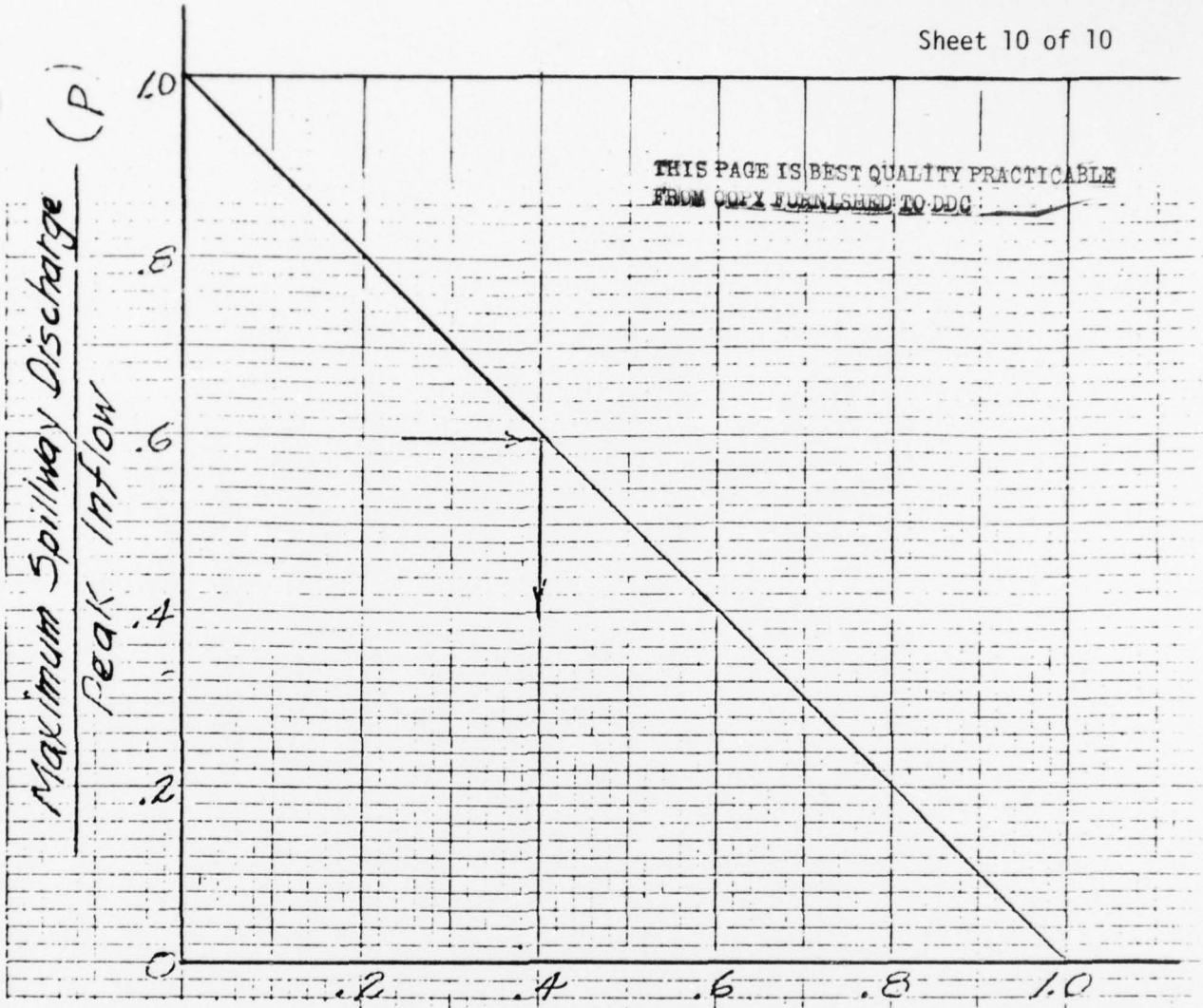
$$\frac{\Delta AOC}{\Delta AOB} = 1 - \frac{T \rho Q_I \text{ max}/2}{T\ Q_I \text{ max}/2} = 1 - \rho$$

$$\Delta AOC = (1-\rho)\,\Delta AOB \quad \text{where } 0 \le \rho \le 1.0$$

ρ	ΔAOC
1.00	0
0.75	0.25 ΔAOB
0.50	0.50 ΔAOB
0.25	0.75 ΔAOB
0	1.00 ΔAOB

REFERENCE

PRELIMINARY ENGINEER TECHNICAL LETTER NO. 1110-2-
25 January 1978

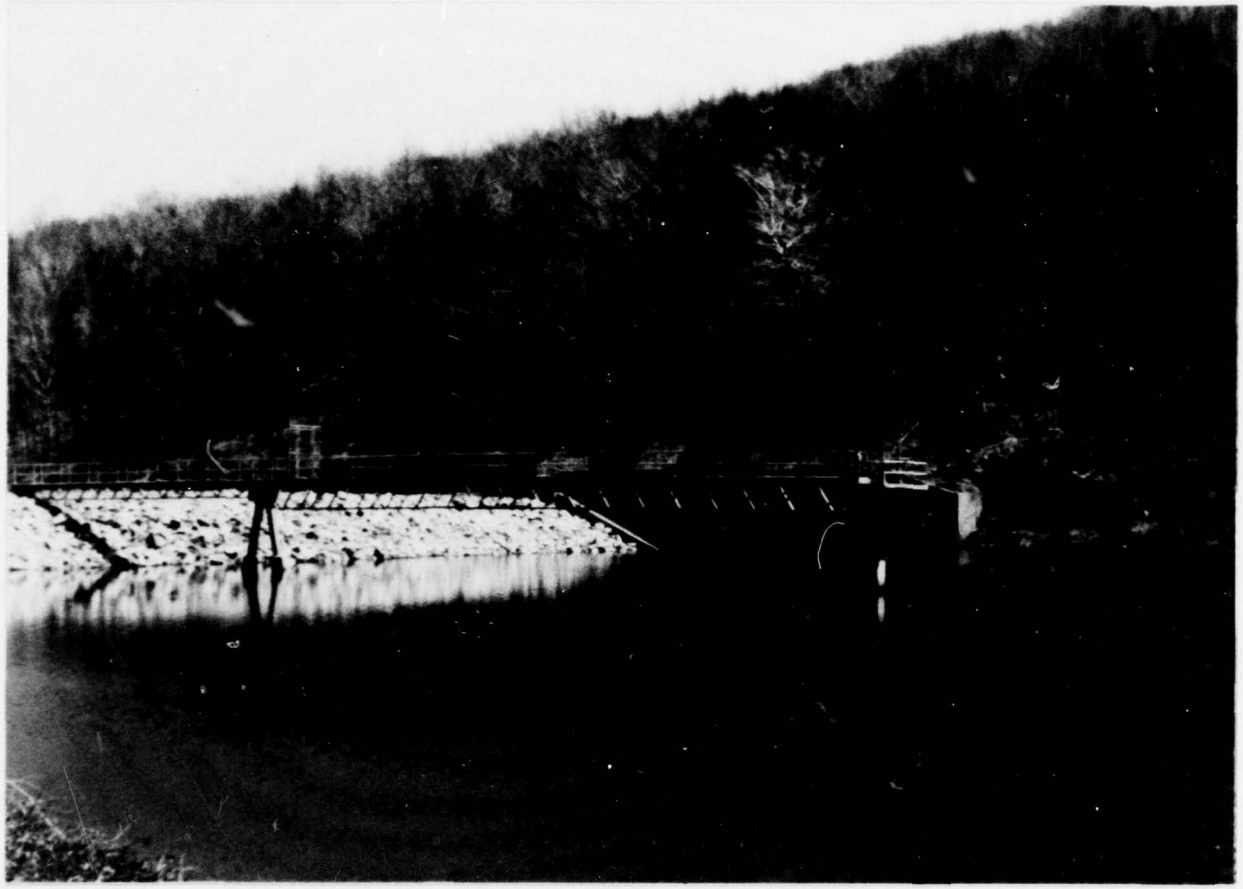


Steps to obtain required reservoir to pass inflow hydrograph without overtopping dam.

1. Obtain maximum spillway discharge
2. Develop inflow hydrograph
3. Compute relationship of maximum spillway capacity to peak inflow
4. Read relationship of required reservoir storage to volume of inflow hydrograph from curve

APPENDIX

D



VIEW LOOKING TOWARDS RIGHT ABUTMENT AT
INTAKE TOWER AND EMERGENCY SPILLWAY INTAKE CHANNEL

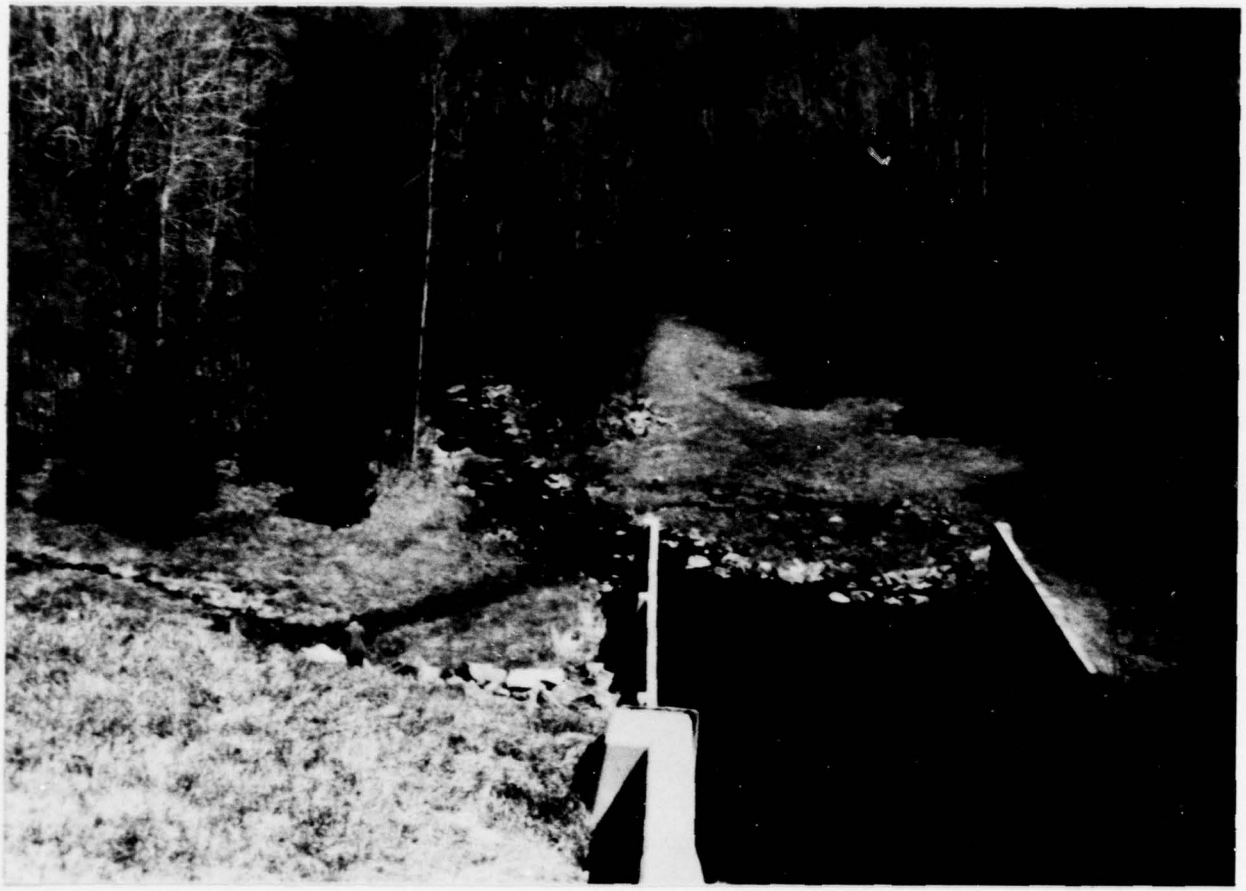
PHOTO NO. 1

VIEW OF DISCHARGE CULVERT AT DOWNSTREAM TOE

PHOTO NO. 2

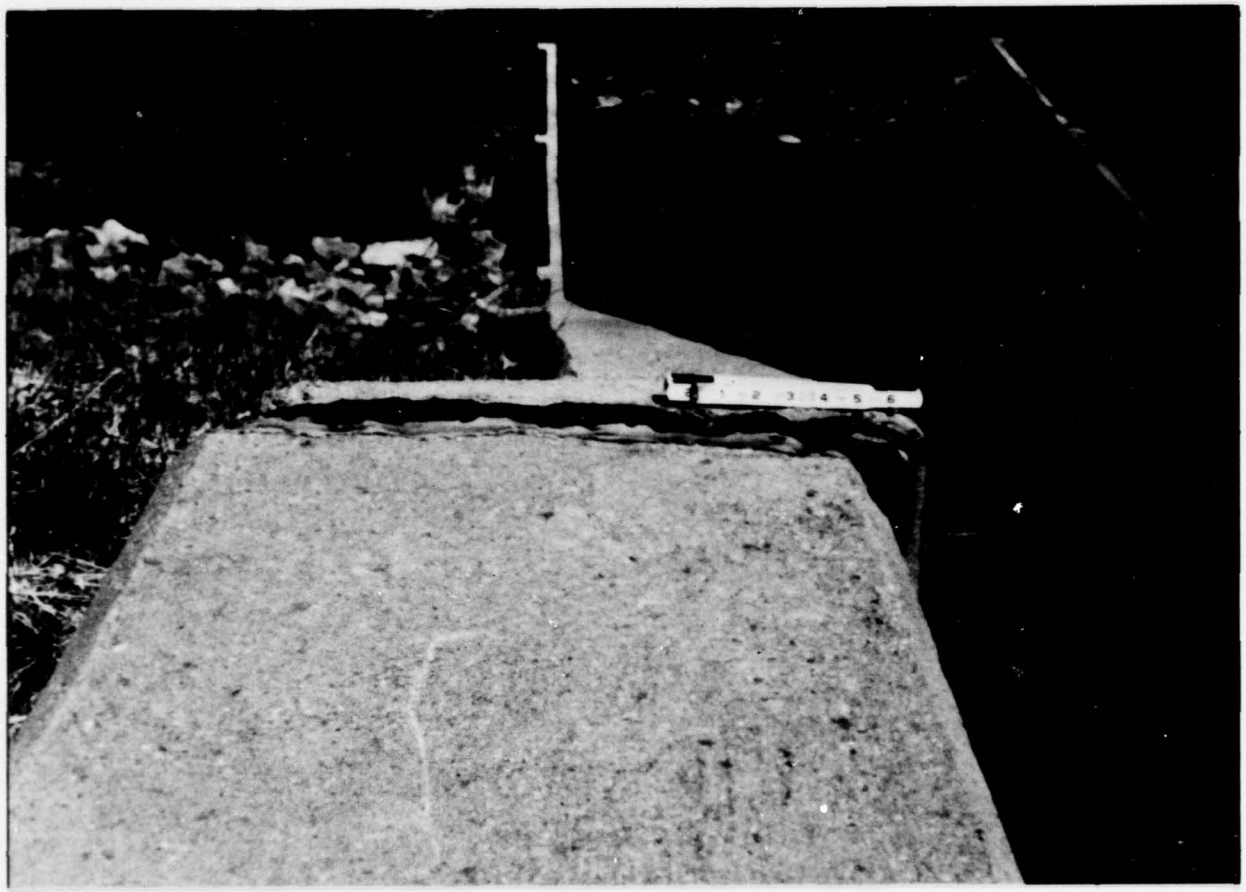
VIEW FROM RIGHT ABUTMENT LOOKING DOWNSTREAM AT SPILLWAY

PHOTO NO. 3



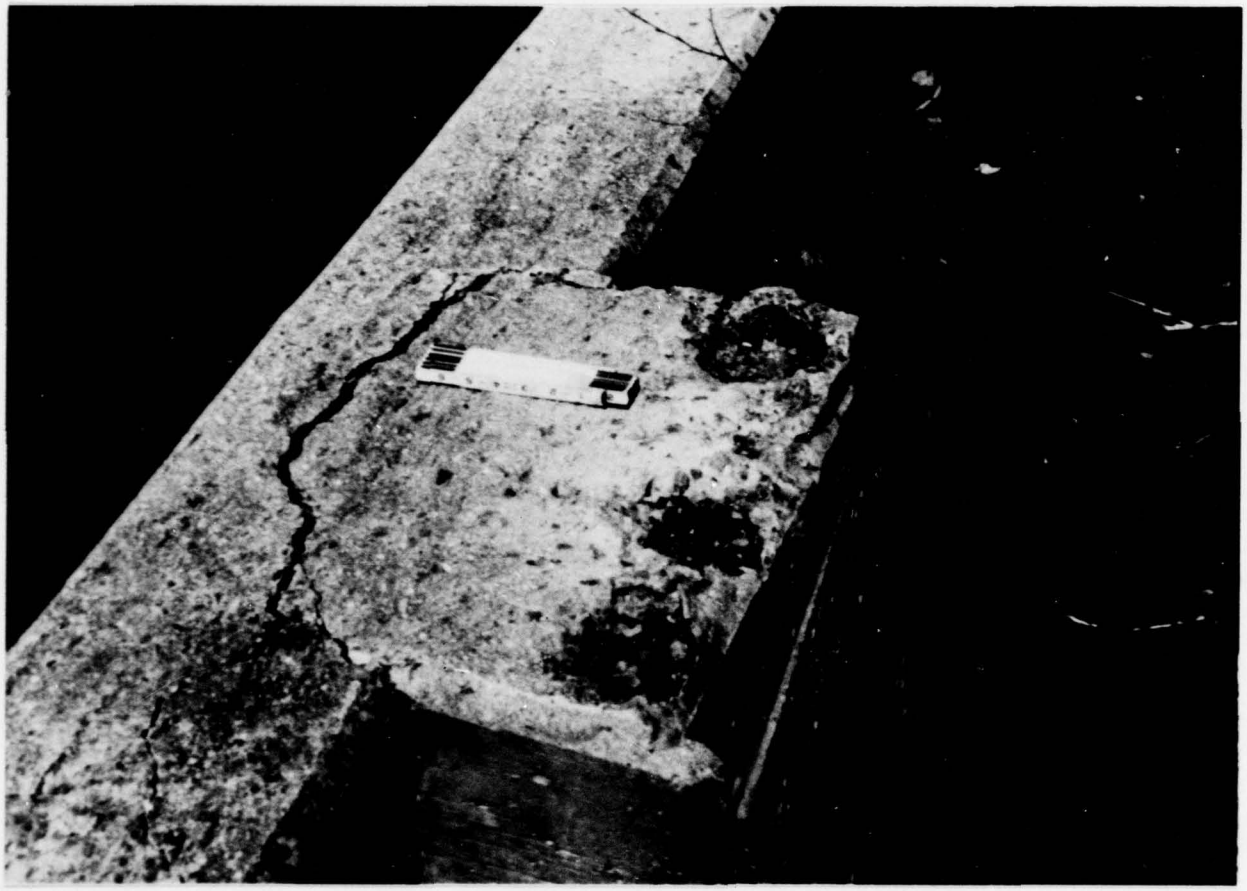
VIEW OF THE SPILLWAY AND DISCHARGE CHANNEL INTO THE NATURAL STREAM CHANNEL.
NOTE WALL DISPLACEMENT AT BUTTRESS IN LOWER CENTER OF PHOTO.
SEE PHOTO NO. 5 FOR DETAILS.

PHOTO NO. 4



VIEW OF 1.5 INCH DISPLACEMENT OF RETAINING WALL
ON LEFT SIDE OF DISCHARGE CHANNEL

PHOTO NO. 5

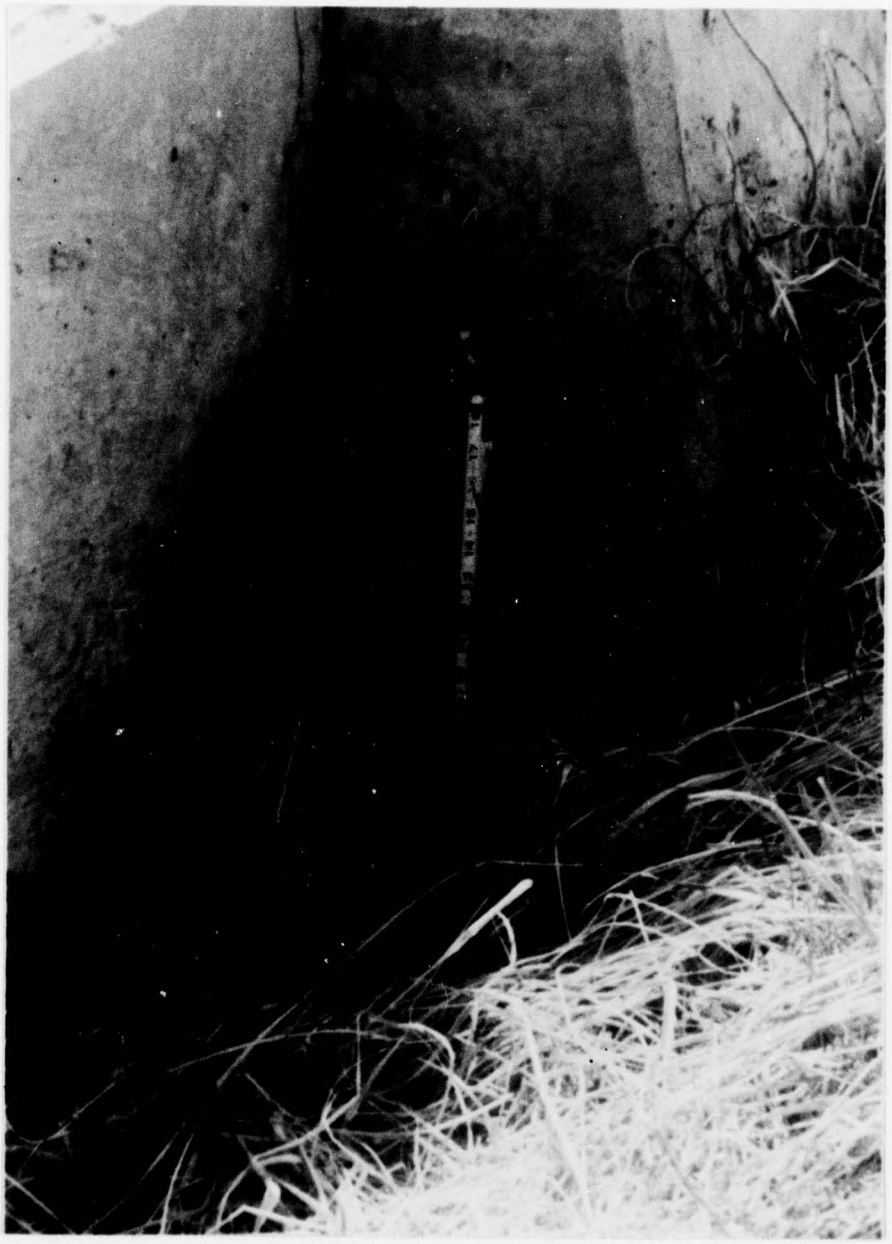


VIEW OF RETAINING WALL AND BUTTRESS SEPARATION
ALONG RIGHT SIDE OF DISCHARGE CHANNEL.

PHOTO NO. 6

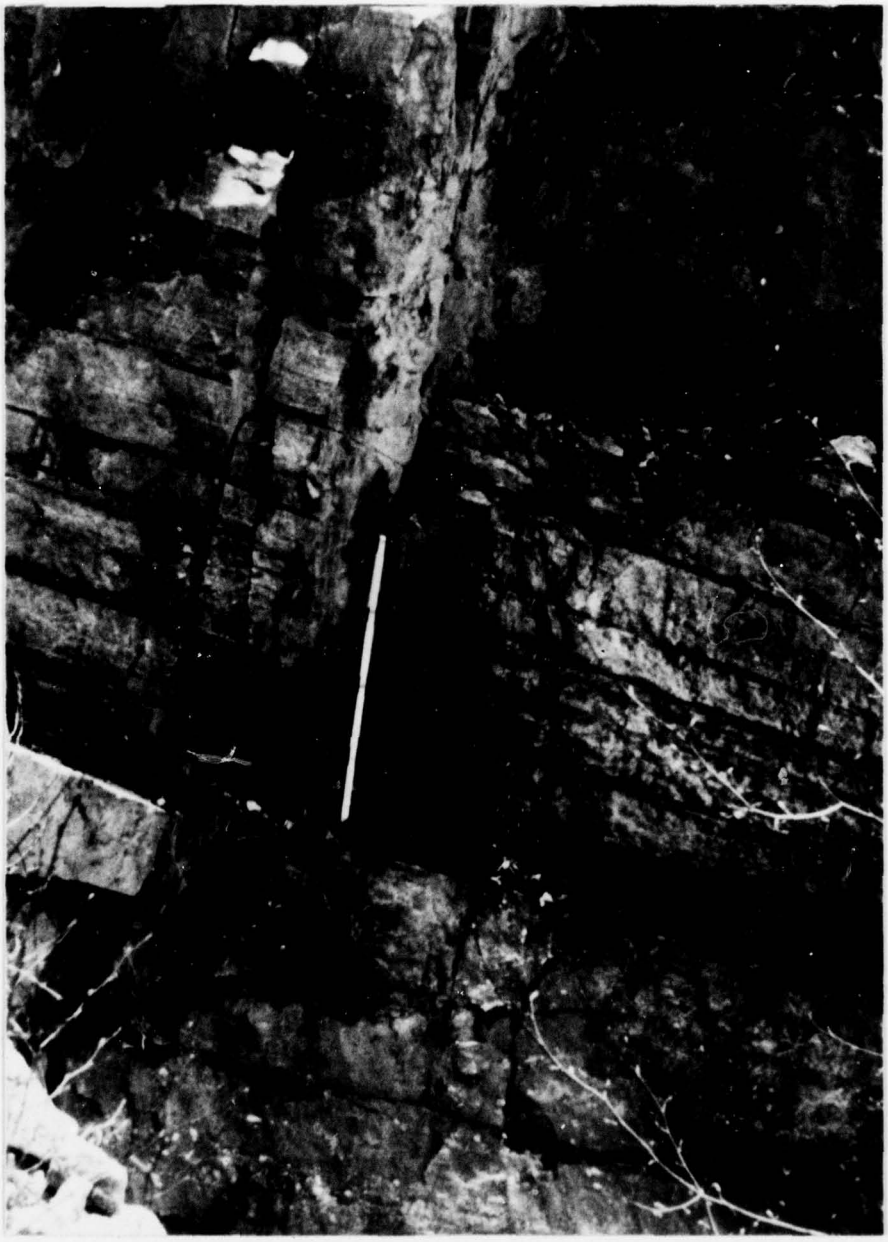
SETTLEMENT OF DAM CREST AT LEFT SPILLWAY WALL.
PHOTO SHOWS 6 to 12 INCHES OF SETTLEMENT.

PHOTO NO. 7



SETTLEMENT OF DOWNSTREAM SLOPE
OF DAM AT LEFT SPILLWAY WALL.
PHOTO SHOWS 12 INCHES OF SETTLEMENT.

PHOTO NO. 8

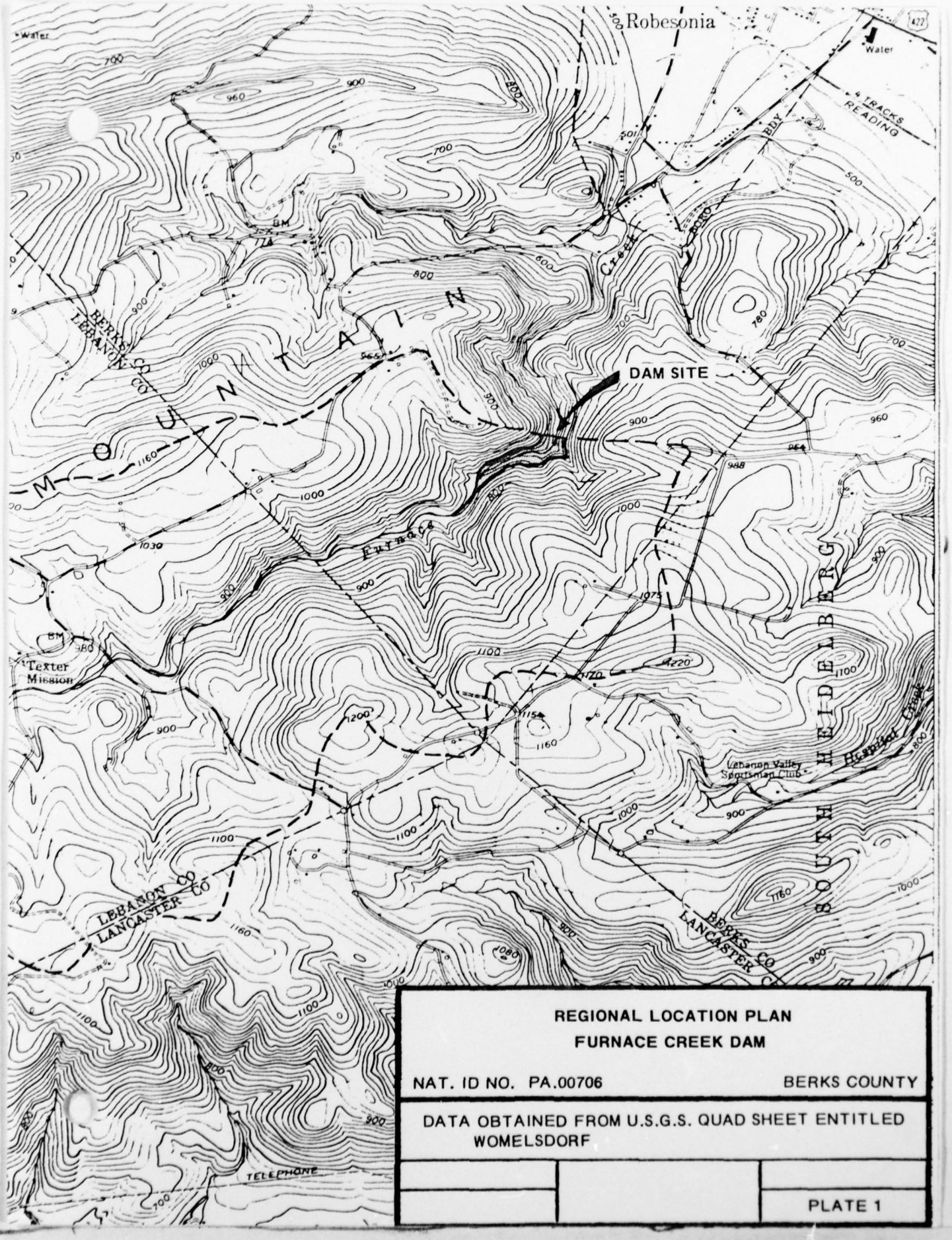


DETAIL OF GRANITE GNEISS EXPOSURE AT
RIGHT ABUTMENT, UPSTREAM
FROM DAM CENTERLINE

PHOTO NO. 9

APPENDIX

E

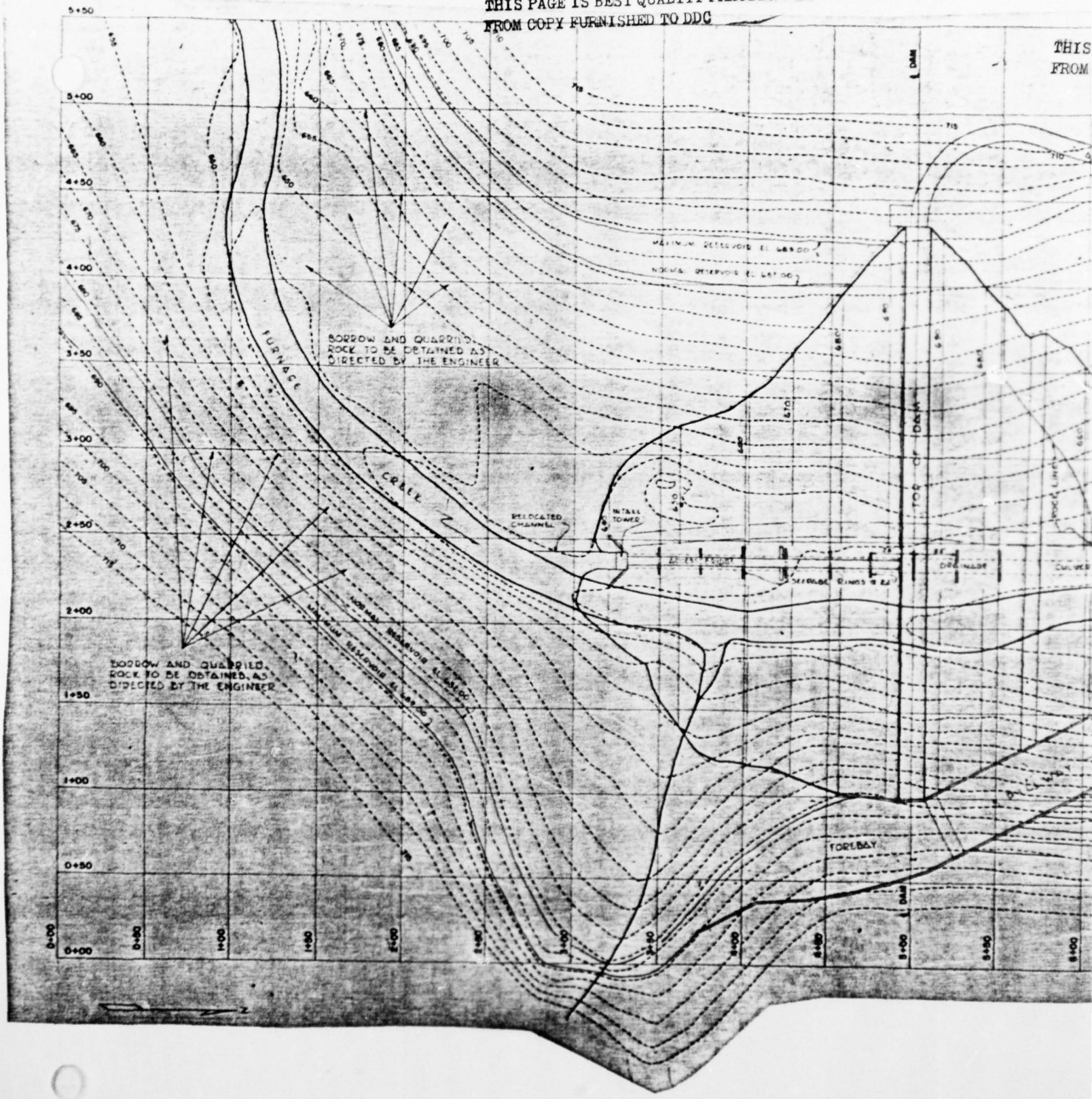


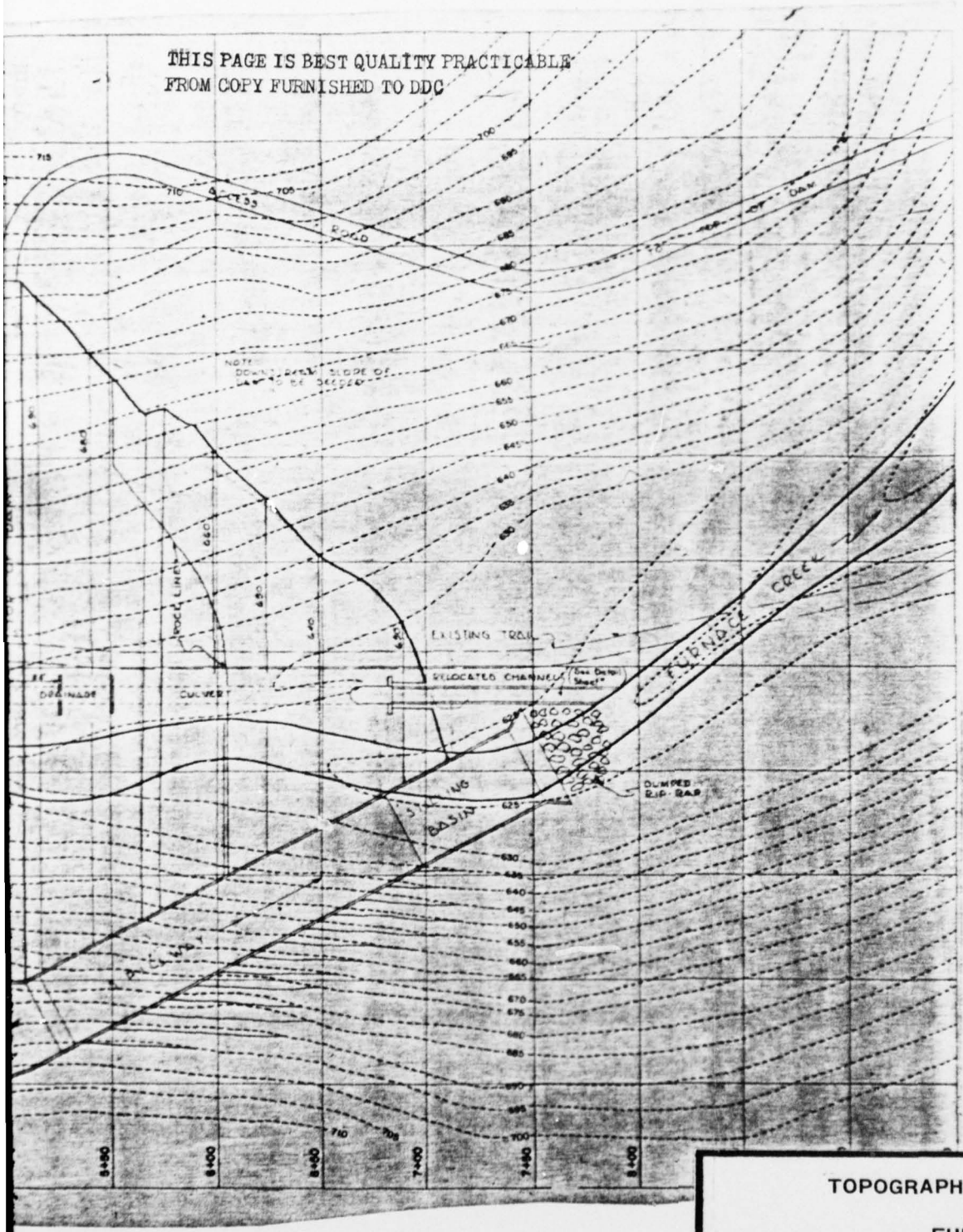
REGIONAL LOCATION PLAN
FURNACE CREEK DAM

NAT. ID NO. PA.00706 BERKS COUNTY

DATA OBTAINED FROM U.S.G.S. QUAD SHEET ENTITLED WOMELSDORF

PLATE 1





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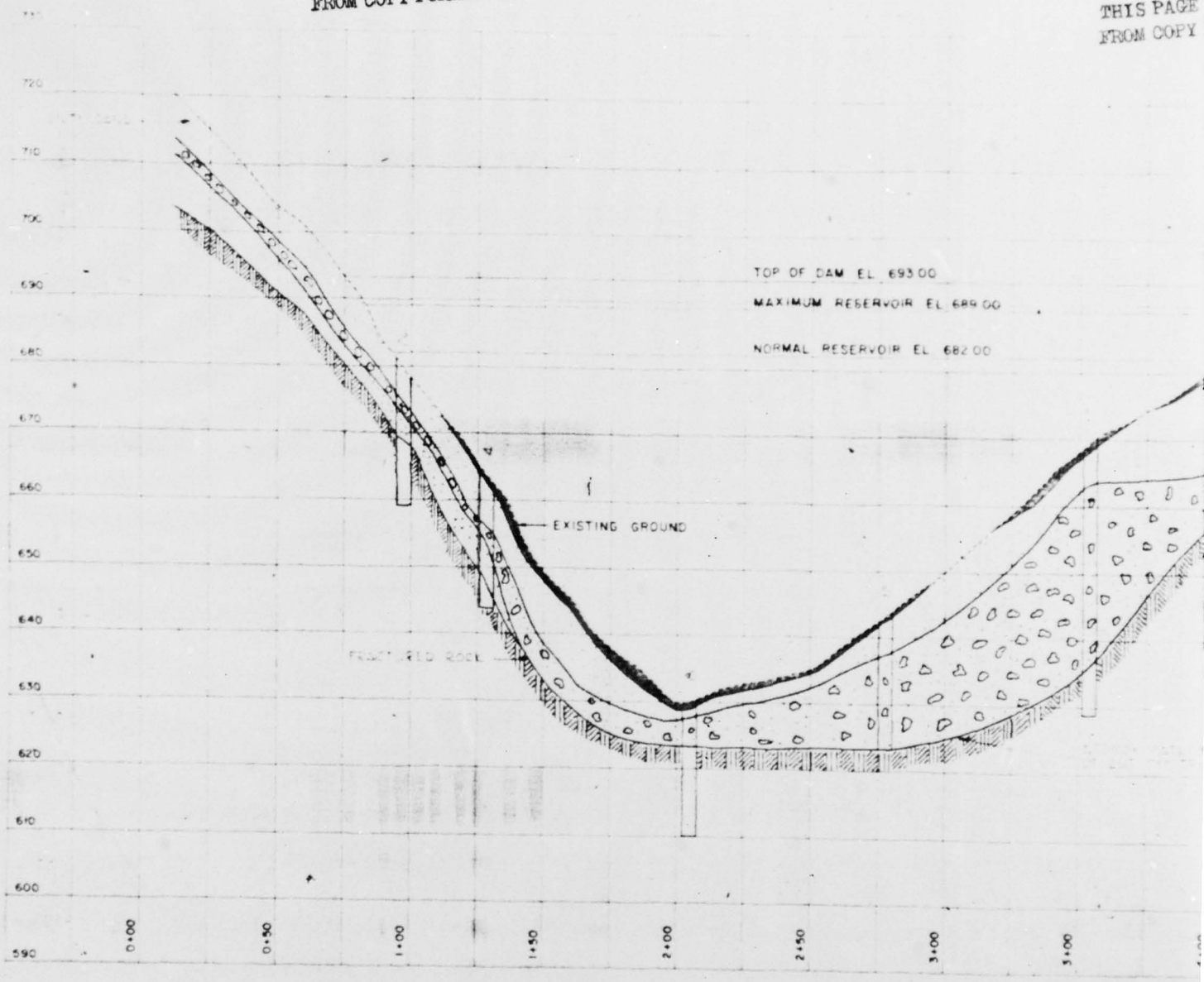
TOPOGRAPHICAL PLAN AND PLAN OF DAM AND SPILLWAY
FURNACE CREEK DAM

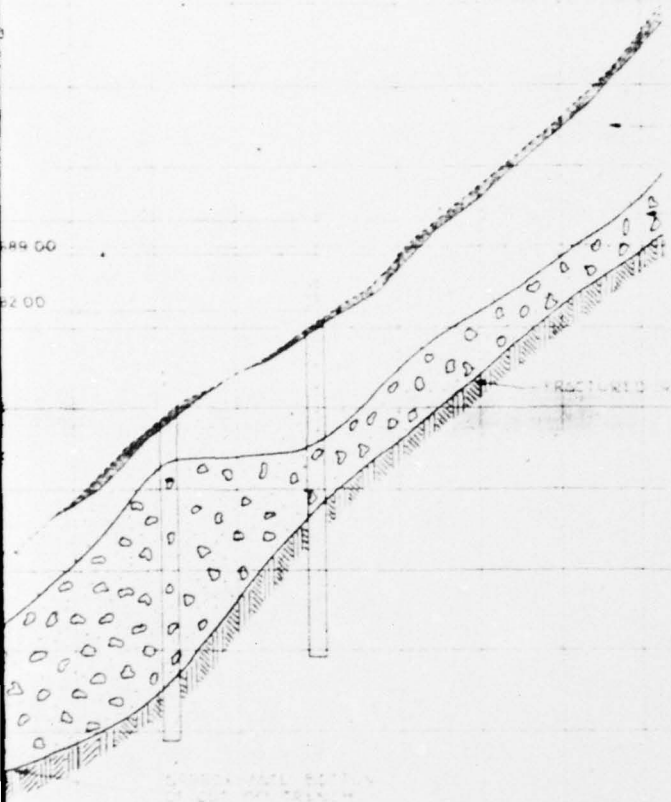
NAT. ID NO. PA.00706 BERKS COUNTY

DATA OBTAINED FROM GLACE AND GLACE CONSULTING ENGINEERS DESIGN DRAWINGS SHEET 9 OF 25 , DATED 10 NOV. 1958

PLATE 2



℄ PROFILE AT SITE OF DAM
STATION 5+00



VERT 1" = 10'
HORZ 1" = 2[illegible]

3+00 4+00 4+50 5+00 5+50

LOAM - VEGETATION
SILTY SAND
SILTY SAND - BOULDERS
GRANITIC GNEISS

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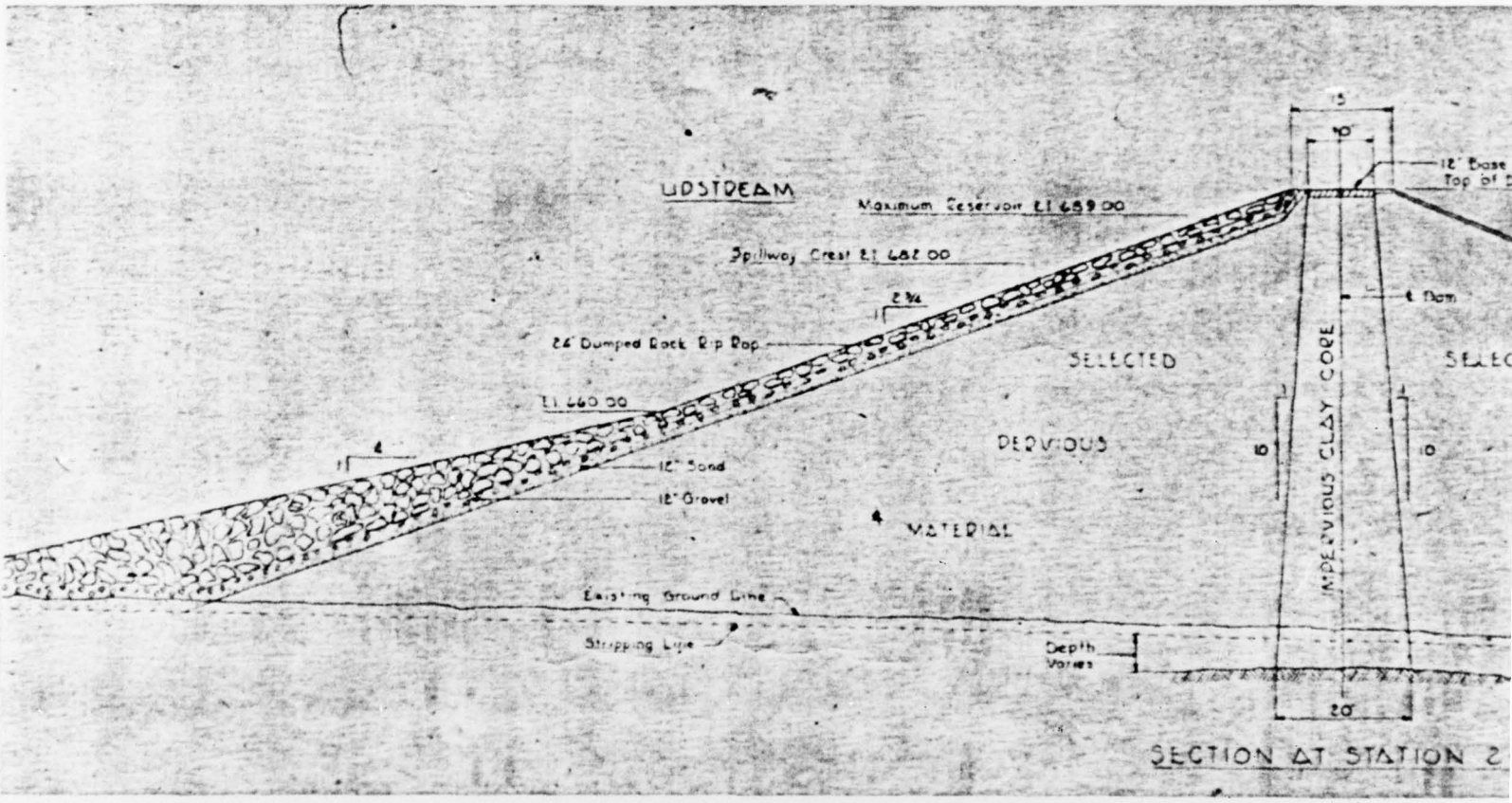
CENTERLINE FOUNDATION PROFILE
FURNACE CREEK DAM

NAT. ID NO. PA.00706 BERKS COUNTY

DATA OBTAINED FROM GLACE AND GLACE CONSULTING ENGINEERS
DESIGN DRAWINGS, SHEET 10 OF 25, FILE 5717.4, DATED 10 NOV.1958

2

PLATE 3



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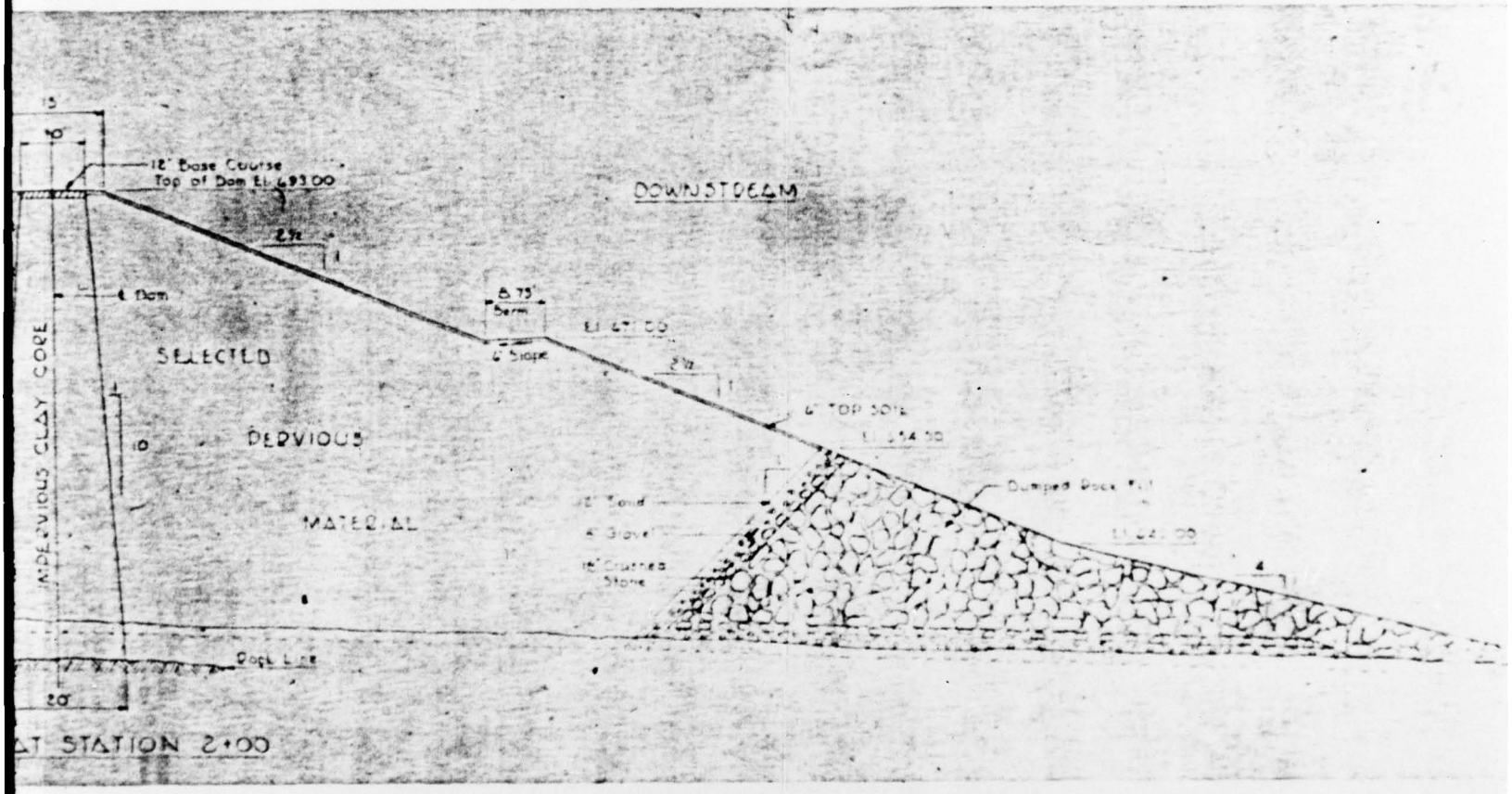
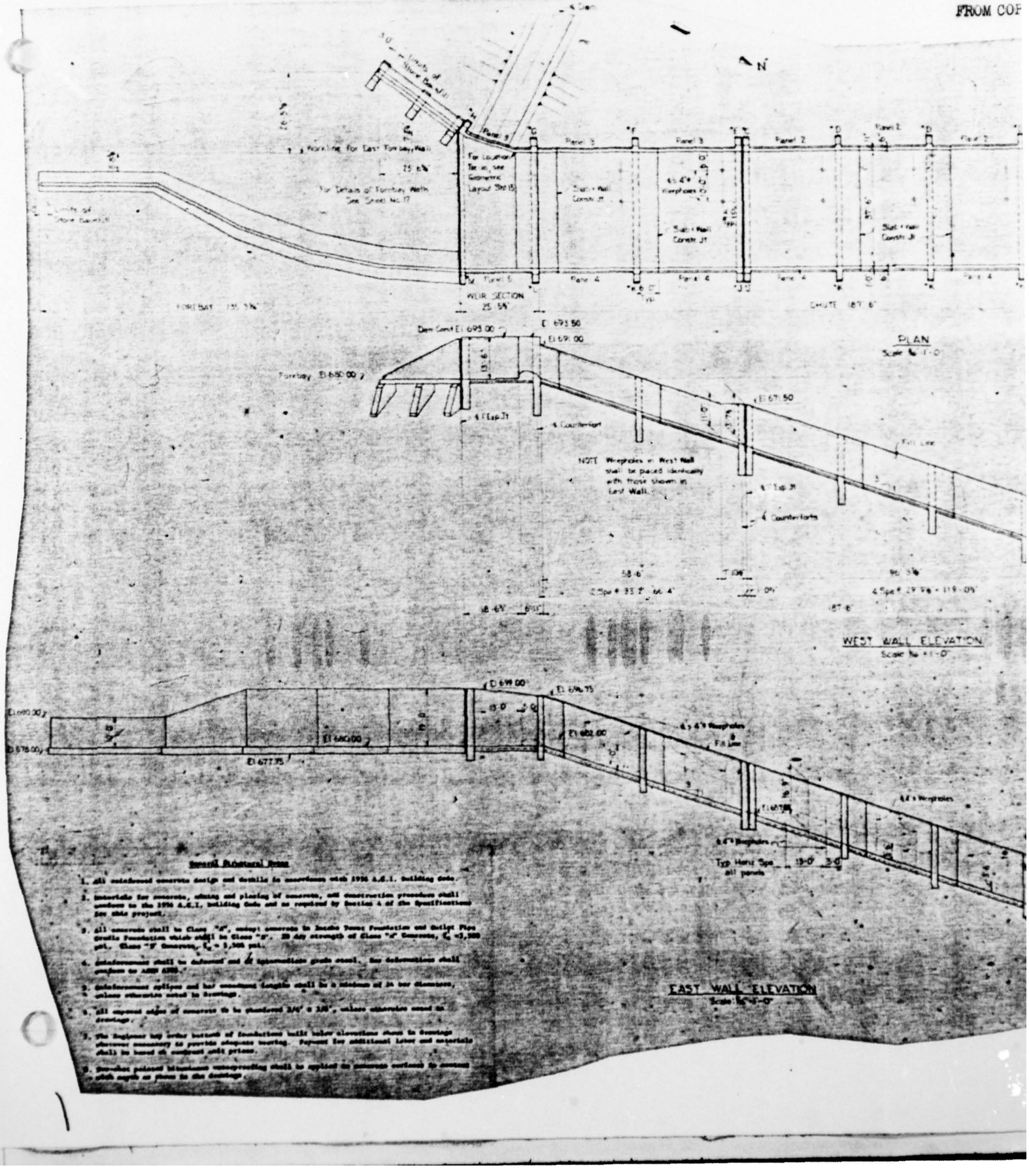


TYPICAL EMBANKMENT SECTION
FURNACE CREEK DAM

NAT. ID NO. PA.00706 BERKS COUNTY

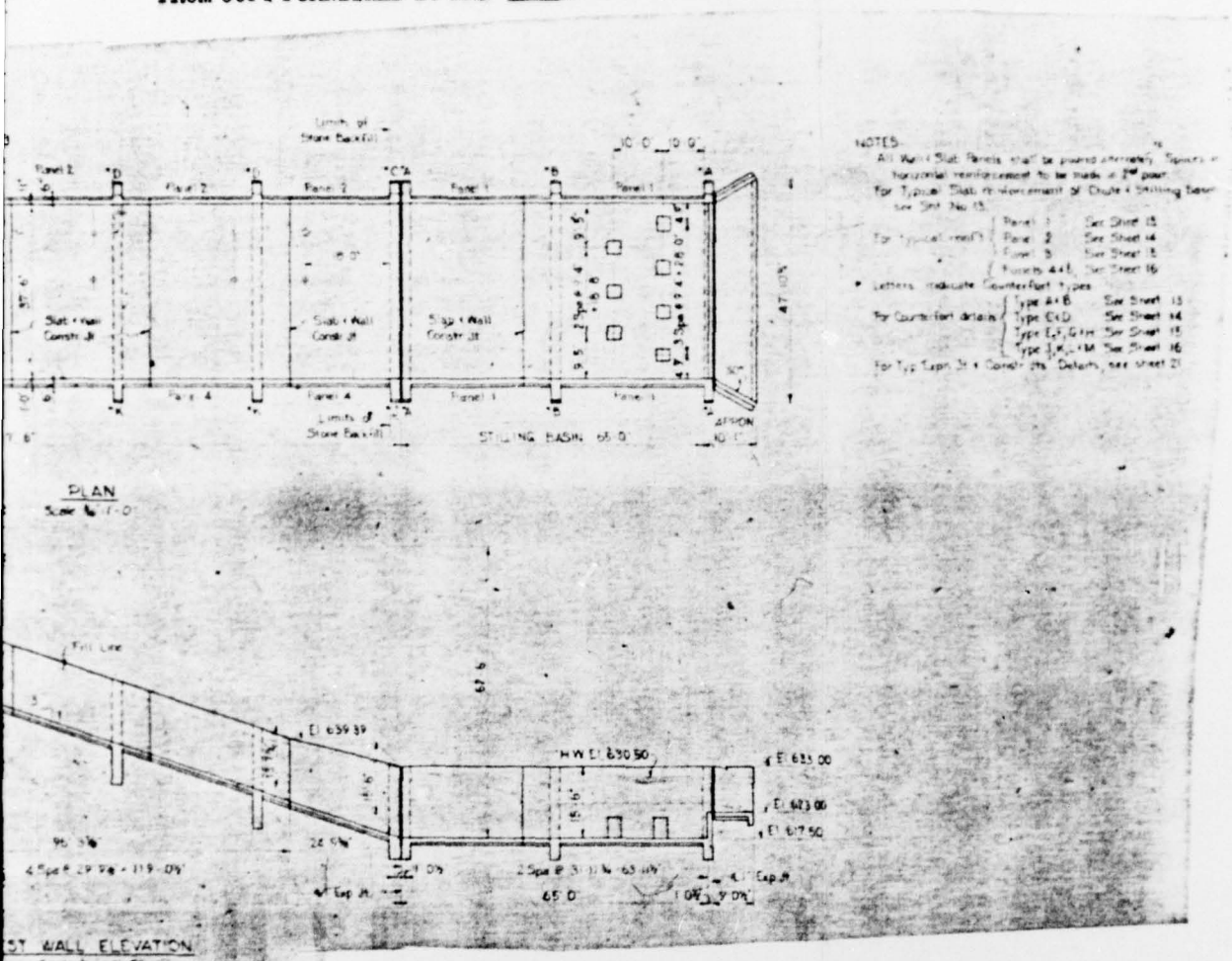
DATA OBTAINED FROM GLACE AND GLACE CONSULTING ENGINEERS
DRAWING SHEET 11 OF 25, FILE 5717, DATED 10 NOV. 1958

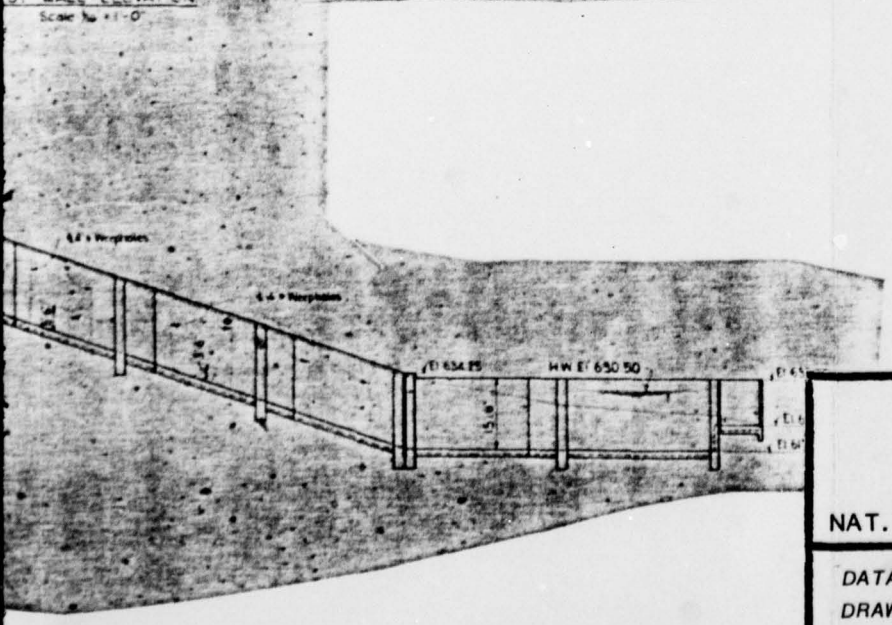
PLATE 4



General Structural Notes

1. All reinforced concrete design and details in accordance with 1956 A.C.I. building code.
2. Materials for concrete, mixing and placing of concrete, and construction procedure shall conform to the 1956 A.C.I. building code and as required by Section 4 of the Specifications for this project.
3. All concrete shall be Class "A", except concrete in Intake Tower Foundation and Outlet Pipe Cradle Foundation which shall be Class "B". 28 day strength of Class "A" Concrete, f'_c = 3,000 psi. Class "B" Concrete, f'_c = 2,500 psi.
4. Reinforcement shall be deformed and of intermediate grade steel. Bar deformations shall conform to ASTM A305.
5. Reinforcement splices and bar embedment lengths shall be a minimum of 24 bar diameters, unless otherwise noted in drawings.
6. All exposed edges of concrete to be chamfered 3/4" x 3/4", unless otherwise noted on drawings.
7. The Engineer may order buttress of foundations built below elevations shown in drawings whenever necessary to provide adequate bearing. Payment for additional labor and materials shall be based on contract unit prices.
8. Immediately prior to placement waterproofing shall be applied on concrete surfaces in contact with earth as shown in the drawings.



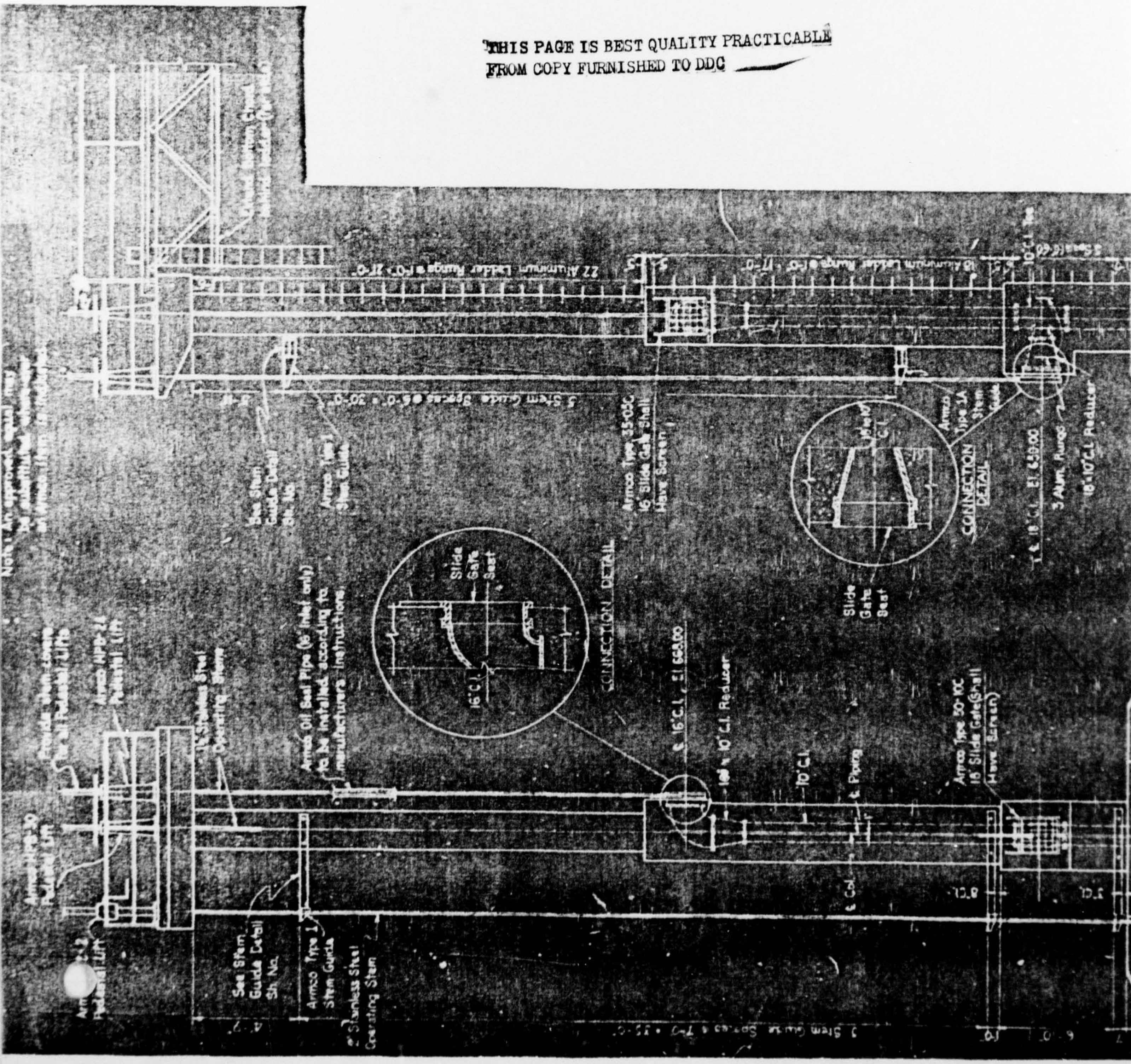


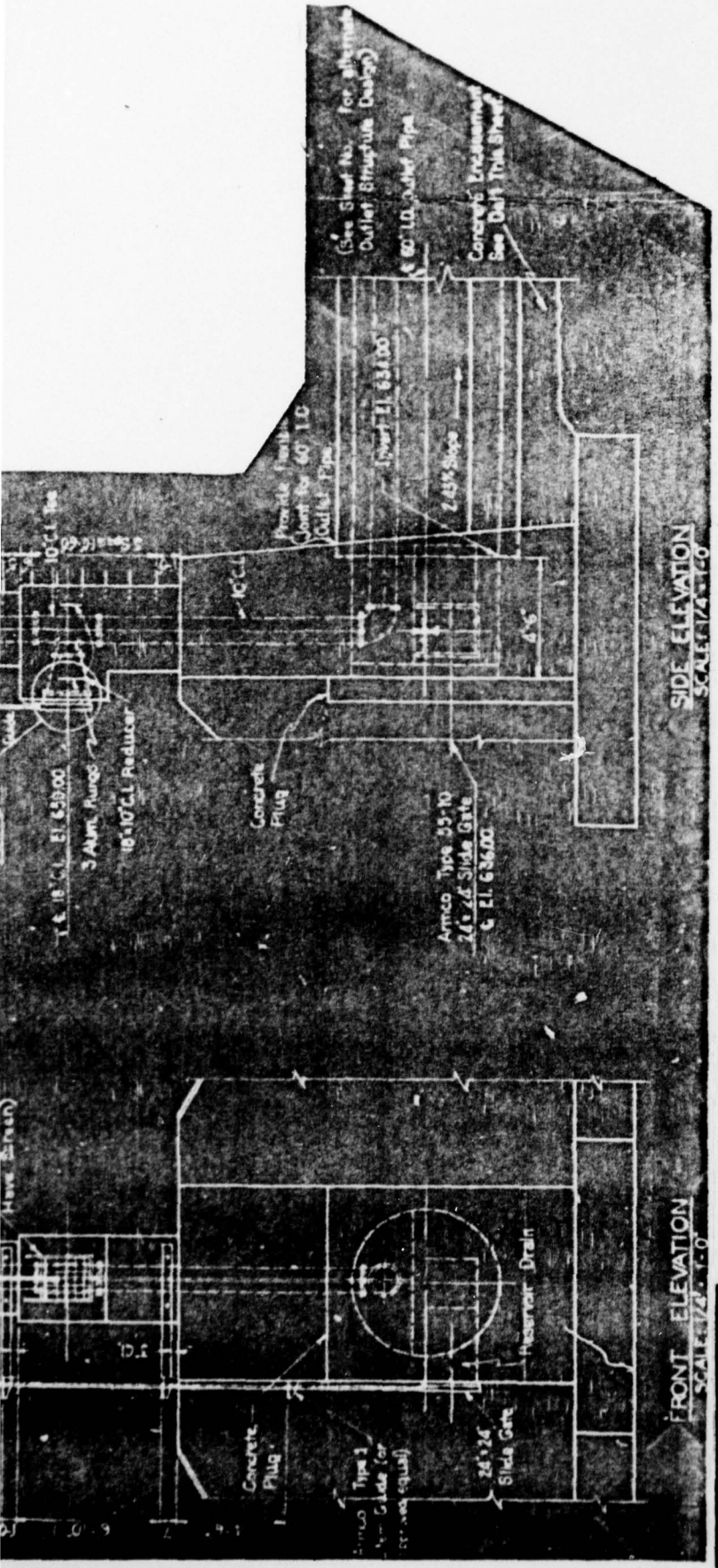
SPILLWAY PLAN AND PROFILE
FURNACE CREEK DAM

NAT. ID NO. PA.00706 BERKS COUNTY

DATA OBTAINED FROM GLACE AND GLACE CONSULTING ENGINEERS
DRAWING SHEET 12 OF 25, FILE 5717.4, DATED 10 NOV. 1958

PLATE 5





INTAKE TOWER
FURNACE CREEK DAM

NAT. ID NO. PA.00706 BERKS COUNTY

DATA OBTAINED FROM GLACE AND GLACE CONSULTING ENGINEERS
DESIGN DRAWINGS SHEET 18 OF 25, DATED 10 NOV. 1958

PLATE 6

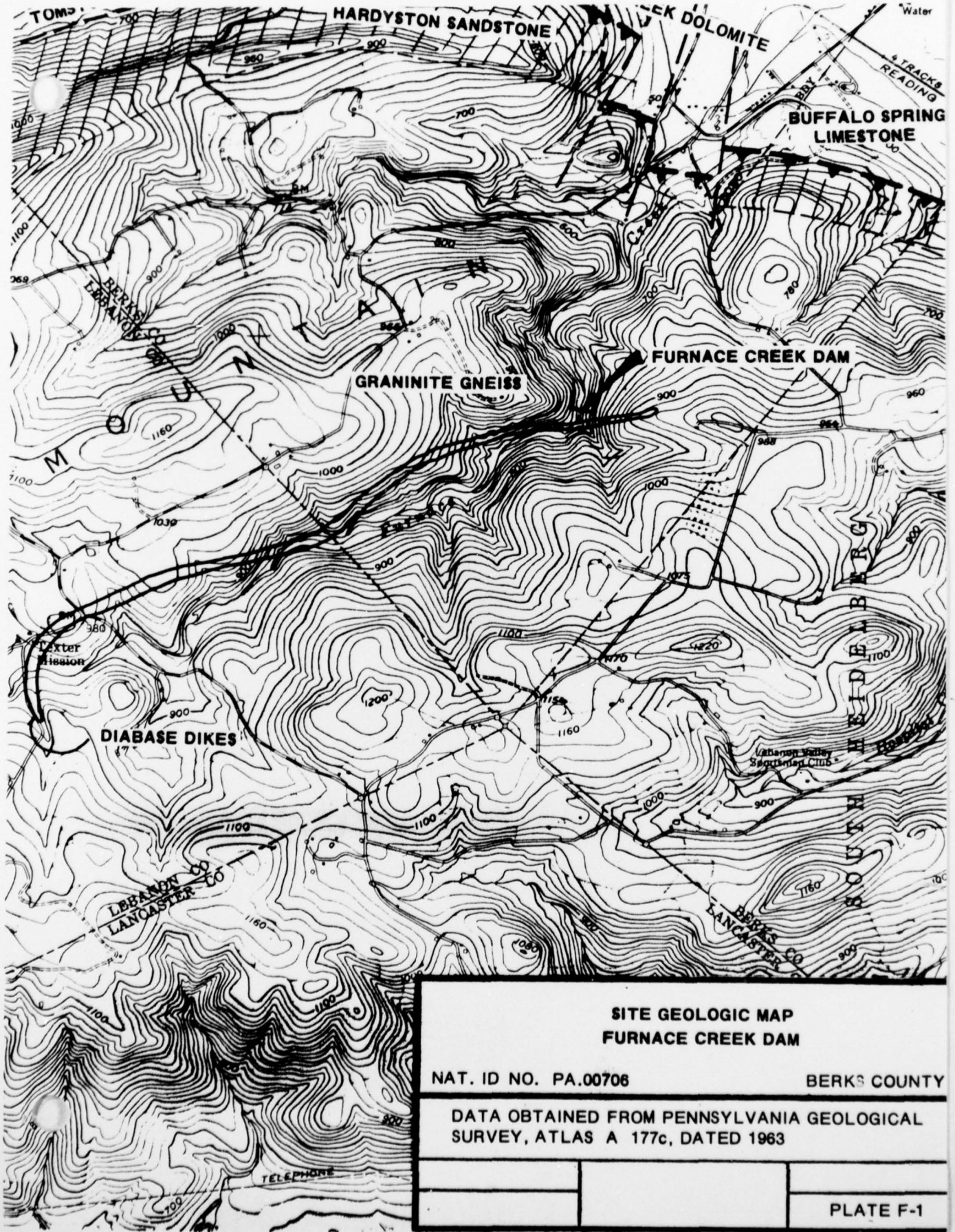
APPENDIX

F

SITE GEOLOGY
FURNACE CREEK DAM

Furnace Creek Dam is located within the boundary between the Great Valley Section of the Valley and Ridge Physiographic Province and the Triassic Lowland Section of the Piedmont Physiographic Province in an area referred to as South Mountain. As shown in Plate F-1, the bedrock in the dam area consists of granite gneiss of Precambrian age. Also present in the immediate dam area is a system of northeast striking diabase dikes. Compositional layering (foliation) in the granite gneiss strikes nearly east-west (subparallel to the dam axis) and dips from 30 to 40 degrees to the south (upstream direction). Jointing in the area strikes both to the northeast and northwest with high angle west and east dips, respectively. The orientation of rock jointing is conducive to downstream water seepage.

The nearest faulting mapped in the area is a series of east-west striking and south dipping thrust faults approximately one mile downstream of the dam near the town of Robesonia.



SITE GEOLOGIC MAP
FURNACE CREEK DAM

NAT. ID NO. PA.00706 BERKS COUNTY

DATA OBTAINED FROM PENNSYLVANIA GEOLOGICAL SURVEY, ATLAS A 177c, DATED 1963

PLATE F-1